Ontario Geological Survey

Report 210

# Geology of the

# Two Horse Lake Area

## District of Algoma

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By

Gerald Bennett

1982

Ontario

Ministry of Natural Resources

Hon. Alan W. Pope
Minister

W.T. Foster
Deputy Minister

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Printed in Canada

ISSN 0704-2582
ISBN No. 0-7743-6756-3

Publications of the Ontario Ministry of Natural Resources
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*Ministry of Natural Resources, Public Service Centre*
*Room 1640, Whitney Block, Queen's Park, Toronto,*
*Ontario, M7A 1W3 (personal shopping and mail orders).*

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Bennett, Gerald
1982: Geology of the Two Horse Lake Area, District of Algoma; Ontario Geological Survey Report 210, 63p. Accompanied by Map 2448, Scale 1:31 680 or 1 inch to ½ mile.

1000-300-80-Thorn

93-00866/

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**GEOLOGICAL MAP**

(back pocket)

Map 2448 (coloured)–Two Horse Lake, Algoma District.
Scale 1:31 680 (1 inch to ½ mile).

# ABSTRACT

This report describes the stratigraphy, structural, and economic geology of the Two Horse Lake area. This area is located about 32 km east-northeast of the city of Sault Ste. Marie, District of Algoma, Ontario, and about 28 km north of the west end of Lake Huron.

The oldest rocks of the area are Early Precambrian (Archean) felsic to intermediate plutonic rocks which underlie the northern part of the map-area. The Early Precambrian rocks are unconformably overlain by a sequence of Middle Precambrian (Huronian) sedimentary and volcanic rocks which have an aggregate stratigraphic thickness of about 5000 m.

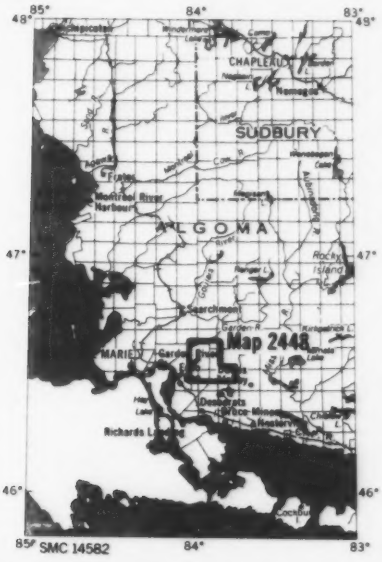


Figure 1–Key map showing location of the Two Horse Lake Area.
Scale 1:3 168 000 or 1 inch to 50 miles.

The Huronian rocks have been subdivided into eight formations. These are: the Livingstone Creek and Thessalon Formations of the Elliot Lake Group; the Ramsay Lake and Mississagi Formations of the Hough Lake Group; the Bruce and Espanola Formations of the Quirke Lake Group; and the Gowganda and Lorrain Formations of the Cobalt Group.

Large sill-like bodies and dikes of Nipissing Diabase which yield radiometric dates of 2 155±80 million years old intrude all the Huronian rocks.

A few diabase dikes of the Sudbury Swarm (1 225±25 million years old) and pink felsite of Keweenawan age represent the youngest rocks of the map-area.

All rocks except the Sudbury Diabase and Keweenawan felsite have been metamorphosed to the lower greenschist facies of regional dynamothermal metamorphism.

For the most part, the Huronian rocks form a homocline striking northwest and dipping to the southwest. Northwest-striking reverse faults as well as northwest- and northeast-striking normal faults are the major structural features of the area.

The major period of metamorphism and structural deformation took place following the intrusion of the Nipissing Diabase, but before the emplacement of the Sudbury and Keweenawan dikes.

Low grade uraniferous, quartz-pebble conglomerates are found intercalated with the basaltic rocks of the Thessalon Formation just east of the map-area. Copper and iron deposits have been prospected in skarn in the Espanola Formation. Skarn has been altered and metamorphosed by adjacent Nipissing Diabase in the Espanola Formation.

Copper-bearing quartz and quartz-carbonate veins are found in the area, but to date none of these have proved to be of sufficient grade and tonnage to warrant mining.

# CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

If the reader wishes to convert imperial units to SI (metric) units or SI units to imperial units the following multipliers should be used:

| CONVERSION FROM SI TO IMPERIAL | | | CONVERSION FROM IMPERIAL TO SI | | |
|---|---|---|---|---|---|
| *SI Unit* | *Multiplied by* | *Gives* | *Imperial Unit* | *Multiplied by* | *Gives* |
| | | | LENGTH | | |
| 1 mm | 0.039 37 | inches | 1 inch | **25.4** | mm |
| 1 cm | 0.393 70 | inches | 1 inch | **2.54** | cm |
| 1 m | 3.280 84 | feet | 1 foot | **0.304 8** | m |
| 1 m | 0.049 709 7 | chains | 1 chain | 20.116 8 | m |
| 1 km | 0.621 371 | miles (statute) | 1 mile (statute) | **1.609 344** | km |
| | | | AREA | | |
| 1 $cm^2$ | 0.155 0 | square inches | 1 square inch | **6.451 6** | $cm^2$ |
| 1 $m^2$ | 10.763 9 | square feet | 1 square foot | **0.092 903 04** | $m^2$ |
| 1 $km^2$ | 0.386 10 | square miles | 1 square mile | 2.589 988 | $km^2$ |
| 1 ha | 2.471 054 | acres | 1 acre | 0.404 685 6 | ha |
| | | | VOLUME | | |
| 1 $cm^3$ | 0.061 02 | cubic inches | 1 cubic inch | **16.387 064** | $cm^3$ |
| 1 $m^3$ | 35.314 7 | cubic feet | 1 cubic foot | 0.028 316 85 | $m^3$ |
| 1 $m^3$ | 1.308 0 | cubic yards | 1 cubic yard | 0.764 555 | $m^3$ |
| | | | CAPACITY | | |
| 1 L | 1.759 755 | pints | 1 pint | 0.568 261 | L |
| 1 L | 0.879 877 | quarts | 1 quart | 1.136 522 | L |
| 1 L | 0.219 969 | gallons | 1 gallon | **4.546 090** | L |
| | | | MASS | | |
| 1 g | 0.035 273 96 | ounces (avdp) | 1 ounce (avdp) | 28.349 523 | g |
| 1 g | 0.032 150 75 | ounces (troy) | 1 ounce (troy) | **31.103 476 8** | g |
| 1 kg | 2.204 62 | pounds (avdp) | 1 pound (avdp) | **0.453 592 37** | kg |
| 1 kg | 0.001 102 3 | tons (short) | 1 ton (short) | **907.184 74** | kg |
| 1 t | 1.102 311 | tons (short) | 1 ton (short) | **0.907 184 74** | t |
| 1 kg | 0.000 984 21 | tons (long) | 1 ton (long) | **1016.046 908 8** | kg |
| 1 t | 0.984 206 5 | tons (long) | 1 ton (long) | **1.016 046 908 8** | t |
| | | | CONCENTRATION | | |
| 1 g/t | 0.029 166 6 | ounce (troy)/ ton (short) | 1 ounce (troy)/ ton (short) | 34.285 714 2 | g/t |
| 1 g/t | 0.583 333 33 | pennyweights/ ton (short) | 1 pennyweight/ ton (short) | 1.714 285 7 | g/t |

**OTHER USEFUL CONVERSION FACTORS**

| | | |
|---|---|---|
| 1 ounce (troy)/ton (short) | 20.0 | pennyweights/ton (short) |
| 1 pennyweight/ton (short) | 0.05 | ounce (troy)/ton (short) |

NOTE–Conversibn factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries published by The Mining Association of Canada in co-operation with the Coal Association of Canada.

# Geology
# of the
# Two Horse Lake Area
## District of Algoma

By

Gerald Bennett[1]

## INTRODUCTION

The centre of the Two Horse Lake area is located about 32 km east-northeast of the city of Sault Ste. Marie and 28 km north of the west end of Lake Huron.

The area comprises 201 km$^2$ or about three quarters of the Ministry of Natural Resources, Forest Reserve Inventory Sheet 465834. The remainder of the sheet was mapped at a scale of 1 inch to one quarter of a mile by F.J. Chandler in 1970 and its geology is described by F.J. Chandler (1970a, 1970b, 1973).

The boundary of the current map-area may be defined by the co-ordinates of two adjoining rectangles (see Figure 1). The smaller rectangle is bounded by Latitudes 46°30′00″ – 46°31′47″ and Longitudes 83°45′00″ – 83°50′20″. The larger rectangle is bounded by Latitudes 46°30′00″ – 46°37′30″ and Longitudes 83°50′20″ – 84°00′00″. The area consists of almost the whole of Kehoe Township, all Chesley Additional Township, as well as adjoining parts of Aberdeen, Aberdeen Additional, Chesley, MacDonald, and Meredith Townships.

The southern half of the map-area is easily reached by gravel surfaced all-weather roads from Highway 638. The northern parts of Kehoe and Chesley Additional Townships can only be reached on foot along old logging roads.

### Field and Laboratory Work

Geological mapping was done during the summer of 1976 at a scale of 1:15 840 (1 inch to ¼ mile) for publication at a scale of 1:31 680 (1 inch to ½ mile). A preliminary geological map at 1:15 840 (1 inch to ¼ mile) was published in 1977 (Bennett *et al.* 1977).

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[1]Geologist, Ontario Geological Survey.

Manuscript approved for publication by the Chief Geologist, 5th September 1979.
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Traverses were spaced about 400 m apart. Where possible, field data was recorded on transparent mylar overlays over black and white air photographs supplied at a scale of approximately 1:15 840 by the Air Photo Library, Ontario Ministry of Natural Resources. Cronaflex (mylar) base maps were prepared by the Cartography Section, Division of Lands, Ontario Ministry of Natural Resources. A Ryker Sketchmaster was used to transfer data from mylar overlays to the basemaps.

Outcrops not visible on air photographs were located by pace and compass traverses controlled by topographic tie-points. Small, closely spaced outcrops are grouped together to permit reproduction of the map-area at a scale of 1:31 680.

Assays, X-ray diffractions, and chemical analyses were done by the Geoscience Laboratories, Ontario Geological Survey, unless otherwise stated. Modal analyses of thin sections are based on at least 500 points. Thin sections of sedimentary rocks were stained using sodium cobaltinitrite for the identification of potassium feldspars. Optical measurements and plagioclase feldspar determinations were made on a five axis universal stage using the method of A.C. Tobi (1963).

## Previous Work

The current map-area was included in the Bruce Mines map-area accompanying W.H. Collins' 1925 Memoir (Collins 1925). This is the first useful published report describing the essential geological features of the area. Collins gave R.C. Emmons credit for mapping much of the area between Echo Lake and Otter Lake (Collins 1925).

In 1959, M.J. Frarey's preliminary map of the Echo Lake area was published at a scale of 1:63 360 (1 inch to 1 mile), and a revised final map was published in 1975 (Frarey 1959, 1975).

The geology of the area has been compiled at a scale of 1:253 440 by P.E. Giblin and E.J. Leahy (1967).

The office of the Resident Geologist of the Ministry of Natural Resources at Sault Ste. Marie and the Assessment Files Research Office, Ontario Geological Survey, Toronto, contain records of work carried out by mining companies and individuals that have been submitted for assessment work credit.

## Mineral Exploration

The discovery of important copper deposits near Bruce Mines in 1846 undoubtedly led to the initiation of mineral exploration along the North Shore of Lake Huron. Although records do not exist, it is likely that prospectors have visited the Two Horse Lake area since the mid 1800s.

When A.P. Coleman visited the Echo Lake area in 1899, considerable development had already been done by the Austin Mining Company (Ontario Bureau of Mines 1890) and a copper prospect north of Echo Lake (Coleman 1899).

There are virtually no records of exploration activity in the area from the

turn of the century until the late 1940s. In 1955, Lock City Copper Mines did additional work on the Austin copper prospect and Pitch-Ore Uranium Limited drilled a copper-cobalt showing in diabase near Echo Lake.

In 1963 and 1964, the Conwest Exploration Company Limited and New-Senator Rouyn-Limited tested an interesting chalcopyrite-magnetite skarn in Aberdeen Additional Township.

Between 1968 and 1970, Gulf Minerals (Canada) Limited carried out geophysical and geological surveys and a limited diamond drill program in a search for uranium over much of the southwestern part of the map-area.

Safari Explorations Limited attempted to locate extensions of the chalcopyrite-magnetite skarn deposit near Two Horse Lake in 1970.

Since 1970, there has been little exploration activity in the Two Horse Lake area. During the summer of 1976, D. Morningstar restaked a chalcopyrite occurrence in Kehoe Township, and geologists of Shell Oil (Canada) Limited did detailed geological mapping over the Thessalon Formation north of Bass Lake in Aberdeen Township.

### Acknowledgments

The author was competently assisted during the field program by P.J. Whittaker who acted as senior assistant, and who was responsible for much of the mapping. Stephen Friday, Myron Sawiuk, and Les Stegenga assigned as junior assistants, provided able and willing help throughout the field season. Sawiuk did some independent mapping. Dr. M.J. Frarey of the Geological Survey of Canada kindly provided the author with a manuscript copy of his report on the geology of the area between Blind River and Sault Ste. Marie, which was of great value in the preparation of this report.

## GENERAL GEOLOGY

The map-area lies almost entirely within the Southern Province of the Canadian Shield. A small area of Early Precambrian granitic rocks of the Superior Province is found in the northern part of the area. The granitic rocks are unconformably overlain by the predominantly sedimentary rocks of the Huronian Supergroup.

The Huronian rocks have been subdivided into eight formations using the scheme proposed by the Federal Provincial Committee on Huronian Stratigraphy (Robertson *et al.* 1969). These are: the Livingstone Creek and Thessalon Formations of the Elliot Lake Group; the Ramsay Lake and Mississagi Formations of the Hough Lake Group; the Bruce and Espanola Formations of the Quirke Lake Group; and the Gowganda and Lorrain Formations of the Cobalt Group.

Large sill-like bodies of Nipissing gabbro intrude the Huronian rocks. After the intrusion of the gabbros, the Huronian succession was subjected to regional dynamothermal metamorphism which corresponds to the lower greenschist facies.

Within the map-area, the Huronian rocks mainly form a homocline striking northwest and dipping to the southwest. Northwest- and northeast-striking faults are the dominant structural features of the area.

# Precambrian

## EARLY PRECAMBRIAN

Early Precambrian plutonic and hypabyssal rocks of the Superior Province of the Canadian Shield underlie the northern part of Chesley Additional Township and the southeastern corner of Chesley Township. The plutonic rocks, which may be termed "granitic" in a general sense, consist of younger, quartz monzonite and an older granodiorite to gabbro complex found mainly in the northeast corner of Chesley Additional Township.

### *QUARTZ MONZONITE*

The quartz monzonite is a medium- to coarse-grained, pale grey weathering, pink to red granitic rock. It consists of about equal proportions of equigranular and porphyritic phases. The latter contains up to 20 percent of euhedral pink potassium feldspar phenocrysts up to 3 cm long. Contacts between equigranular and porphyritic phases were not observed in the field, and are probably gradational. The quartz monzonite is generally massive, but locally, a faint foliation or trains of mafic schlieren reveal a primary planar structure.

In thin section, the quartz monzonite displays an hypidiomorphic granular texture. Potassium feldspar occurs as large, relatively unaltered, interstitial, anhedral to subhedral grains of microcline commonly containing several euhedral crystals of altered plagioclase (albite) about 1 mm long. The thin sections examined did not contain any of the potassium feldspar phenocrysts.

The plagioclase is typically filled with scaly micaceous alteration products. Optical measurements on a few relatively clear grains indicate that it is albite. Most plagioclase is subhedral to euhedral with well-developed albite twinning.

Quartz is anhedral, strained, and forms interstitial grains and polycrystalline aggregates. Biotite was the predominant original mafic mineral, but has been largely replaced by chlorite.

Locally, the quartz monzonite passes gradationally into a rock containing very little or no quartz and is classified as syenite or quartz syenite (5-10 percent quartz).

### *GRANODIORITE-GABBRO COMPLEX*

An area of felsic to mafic [intermediate on Map 2448, back pocket] plutonic rocks including granodiorite, quartz diorite, diorite, and gabbro, is found near

TABLE 1 | TABLE OF LITHOLOGIC UNITS FOR THE TWO HORSE LAKE AREA.

PHANEROZOIC

CENOZOIC

QUATERNARY

Sandy till, fluvial gravel and sand, silt, clay, swamp deposits.

*Unconformity*

PRECAMBRIAN

LATE PRECAMBRIAN

MAFIC INTRUSIVE ROCKS

Diabase, lampropyre, felsite.

*Intrusive Contact*

MIDDLE PRECAMBRIAN

NIPISSING DIABASE

Diabase, gabbro, peridotite, granophyre.

*Intrusive Contact*

HURONIAN SUPERGROUP

COBALT GROUP

LORRAIN FORMATION

Siltstone, sandstone, arkose, subarkose, quartz-pebble conglomerate.

GOWGANDA FORMATION

Matrix-supported conglomerate, clast-supported conglomerate, arkose, subarkose, siltstone, wacke.

QUIRKE LAKE GROUP

ESPANOLA FORMATION

Limestone, skarn, amphibole magnetite hornfels.

BRUCE FORMATION

Matrix-supported polymictic conglomerate, wacke, siltstone.

HOUGH LAKE GROUP

MISSISSAGI FORMATION

Sandstone, subarkose, conglomerate, grit, wacke.

RAMSAY LAKE FORMATION

Matrix-supported polymictic conglomerate, pebbly wacke.

*Unconformity*

ELLIOT LAKE GROUP

THESSALON FORMATION

Basalt, andesite, rhyolite, siltstone, sandstone, quartz-pebble conglomerate, volcanic conglomerate.

LIVINGSTONE CREEK FORMATION

Sandstone, arkose, subarkose.

*Unconformity*

EARLY PRECAMBRIAN

MAFIC INTRUSIVE ROCKS [Not separated from Nipissing Diabase on Map 2448, back pocket]

Diabase, gabbro.

FELSIC TO INTERMEDIATE PLUTONIC ROCKS

Quartz monzonite, granodiorite, diorite, gabbro syenite, migmatite, pegmatite, aplite.

the northeastern corner of Chesley Additional Township. The area, about 1000 m across, is probably a roof pendant or large inclusion of an older granitic complex within the quartz monzonite. Age relationships are shown by a few dikes of quartz monzonite within the complex. The older granitic rocks range from pale grey to pinkish grey granodiorite, through grey, mesocratic quartz diorite to diorite containing about 20 to 30 percent green amphibole.

In thin section, the predominant mineral of these rocks is revealed to be altered sericitic plagioclase (albite) with some interstitial microcline and quartz. The mafic mineral content is estimated to be from about 5 to 30 percent. In contrast to the quartz monzonite, the mafic mineral is generally pale green actinolite replacing hornblende. Chlorite is present as an alteration product of biotite.

Much of the rock within the complex is dark grey-green, medium- to coarse-grained metagabbro. The metagabbro is intruded by a few dikes of grey granitic rocks resembling the granodiorite of the complex. This would suggest that the metagabbro is an early intrusive phase of the complex. Much of the compositional diversity exhibited by the granitic complex seems to be the result of the contamination of granodiorite magma by reaction with the earlier gabbro phase.

#### *MAFIC HYPABYSSAL ROCKS*

The Early Precambrian granitic rocks of the map-area are intruded by a northwest-trending swarm of mafic dikes. Some of these dikes are clearly of Nipissing age because they have been traced across the unconformity into the Huronian rocks. Since there is a much greater density of mafic dikes in the granitic terrain than in the adjacent Huronian, it is very likely that many of these dikes are also of pre-Huronian age.

It was not possible to distinguish pre-Huronian from post-Huronian dikes on the basis of petrographic criteria either in the field or in the laboratory. They all have a simple mineralogy consisting of; plagioclase (albite), actinolite, chlorite-quartz, and are classified as metagabbro or metadiabase.

## MIDDLE PRECAMBRIAN

### Huronian Supergroup

#### ELLIOT LAKE GROUP

##### Livingstone Creek Formation

The term Livingstone Creek Formation was applied by M.J. Frarey (1967) to a sequence of conglomerates and sandstones which lie upon Early Precam-

brian basement in the Thessalon and Sault Ste. Marie areas. In both these areas, the Livingstone Creek Formation is overlain by a thick sequence of predominantly basaltic flows termed the Thessalon Formation (Frarey 1967).

Where examined by the author in the Sault Ste. Marie and Thessalon areas, [outside the map-area], the predominant lithology of the Livingstone Creek Formation is a pale grey weathering, grey, well-sorted, fine-grained subarkose and arkosic wacke characterized by well-developed trough crossbedding. A basal conglomerate of well rounded cobbles and boulders of grey granitic rocks is locally present [not shown on Map 2448, back pocket]. Conglomeratic sandstones, lithic wacke, and quartz arenite are of restricted occurrence; mudstone and quartz-pebble conglomerates were not observed within the Livingstone Creek Formation.

Only a few outcrops of Livingstone Creek Formation were found below the Thessalon Formation in northern Aberdeen Township. These outcrops are mainly fine- to coarse-grained, grey to yellowish grey weathering, grey, subarkose and arkose. Some exposures of poorly sorted grey, highly feldspathic arkose resemble the lower part of the Livingstone Creek Formation in the Sault Ste. Marie area. Also present are a few outcrops of fine-grained, well-sorted grey, crossbedded subarkose characteristic of the Livingstone Creek Formation. The base of the Livingstone Creek Formation in the map-area has been cut off by the McMahon Lake Fault so that no estimate of its original thickness can be given.

## Thessalon Formation

In northern Aberdeen Township, the grey sandstones of the Livingstone Creek Formation are overlain by a thick series of predominantly mafic metavolcanics and minor interflow metasediments known as the Thessalon Formation (Frarey 1967, 1975; Chandler 1973). The most reliable attitudes on planar amygdaloidal units and bedding in interflow metasediments indicate that the assemblage dips about 35 degrees to the southwest. The present thickness of the Thessalon Formation in Aberdeen Township is estimated to be between 800 to 1200 m. This estimation ignores the possibility of unidentified faults.

### *MAFIC METAVOLCANICS*

The Thessalon Formation is composed mainly of metamorphosed mafic flows which generally weather to various shades of grey or brownish grey. Fresh surfaces are medium grey, grey-green, dark greenish grey, and dark reddish brown with reddish brown stilpnomelane-rich patches. The reddish to brownish hued stilpnomelane-bearing flows appear to be restricted to the lower half of the formation. Modal analyses of two rocks from the Thessalon Formation are given in Table 2.

Amygdules, ranging from microscopic dimensions up to several centimetres across, are almost ubiquitous features of the mafic flows. They are widely dispersed in the central parts of individual flows, but form up to 90 percent of

TABLE 2 MODAL ANALYSES OF ROCKS OF THE THESSALON FORMATION, TWO HORSE LAKE AREA.

| | Modal Analyses | (Volume Percent) |
|---|---|---|
| Sample Number | 1 | 2 |
| Field Number | B8-12 | B37-11A |
| Plagioclase | 41.0 | 40.8 |
| Epidote | 5.5 | — |
| Quartz | Tr | — |
| Actinolite | 8.8 | 31.0 |
| Chlorite | — | 17.2 |
| Stilpnomelane | 41.3 | — |
| Leucoxene | 3.4 | 11.0 |
| Total | 100.0 | 100.0 |

Location of Samples
1. Basaltic-Andesite, Aberdeen Township.
2. Basalt, Aberdeen Township.

Abbreviation
Tr - Trace amount

scoriaceous flow tops. Small amygdules are generally subspherical, but amygdules over 5 cm are commonly irregular due to collapse prior to filling.

The most common amygdule filling is a very dark green to almost black chlorite. Finely granular quartz is also common in amygdules, especially in scoriaceous zones. Calcite, epidote, albite, and stilpnomelane locally fill amygdules either alone, or in combination with other minerals. Thin concentric layers of chalcopyrite and pyrite are present in some amygdules. Minerals, which fill amygdules, are also found filling thin seams and veins in the volcanic rocks.

The mafic flows are generally very fine grained to fine grained (<1 mm). The central parts of thick flows are medium grained (1 to 2 mm), although they form only a minor part of the formation as a whole. Porphyritic (feldsparphyric) and glomeroporphyritic flows are present throughout the sequence. The latter are well developed on the prominent hill overlooking the northeast shore of Aberdeen Lake.

Subconcordant quartz- and albite-filled breccia zones 1 m wide were noted in a few places, but are nowhere as prevalent or as well developed as those in the Duncan Volcanic Belt of the Sault Ste. Marie area (Bennett *et al.* 1975).

For the most part, the central parts of the flows are massive, but highly amygdaloidal flow contacts commonly show a faint to distinct foliation.

Concordant breccia units, a few metres or less thick, consist of closely packed angular to subrounded lapilli to block size fragments of mafic volcanics of differing texture and colour. These units are considered to be pyroclastic breccia or volcanic rubble transported a short distance by intermittent streams.

Only three occurrences of unquestionable pillow lavas were identified within the mafic metavolcanics of the Thessalon Formation. Well-developed pillow structures are found in loose blocks and in outcrops of pale grey weathering, dark grey-green metabasalt on a grassy, dried-up lake bottom around a small pond about mid-way between Bass Lake and McMahon Lake.

The pillow structures are outlined by very fine grained, very dark grey to black selvages from 1 to 3 cm thick. Pillows are from 0.5 m to 1.5 m long, and are elongated in a northwest-southeast direction by a ratio of 3:2 to 3:1. Pillows greater than 1 m in length are generally amygdaloidal. The upper half of the pillow is particularly amygdaloidal. Pillows are tightly packed with thin layers of grey chert separating individual pillows.

A second occurrence of well-developed pillow structures was found about 3 km southeast of, and at about the same stratigraphic level as the one previously described. At this occurrence, thin lenses of dark grey volcanic wacke are found below, and partly within, the pillowed unit.

Under the microscope, it can be seen that the mafic volcanic rocks of the Bass Lake Belt have undergone extensive recrystallization. In most cases, the original, igneous, intersertal, or intergranular textures can barely be discerned.

The original (presumably calcic) plagioclase laths and microlites have been replaced by albite. Pale blue-green to colourless actinolite forms ragged prisms of similar dimensions. Pale green chlorite (penninite) forms interstitial scaly nests. Stilpnomelane is present as masses or patches of needles displaying one to two pleochroic colour schemes. These patches are golden brown to almost black, and pinkish brown to almost black.

Iron and titanium oxides are virtually absent in the mafic volcanic rocks. Much of the iron has presumably been taken up by the mafic silicates. Titanium is present as subrounded to ameboid masses of leucoxene consisting of a very fine mixture of granular sphene, or rutile and silicate alteration products.

The mineral assemblages of the Thessalon Formation identified in thin section correspond to those of the lower greenschist facies metamorphic rank.

### *FELSIC METAVOLCANICS*

A single flow 3 to 4 m thick consisting of pink, amygdaloidal rhyodacite or rhyolite occurs within mafic flows at the eastern end of the volcanic belt about 540 m above the base of the Thessalon Formation. The flow contains about 20 percent amygdules of quartz, calcite, epidote, and some quartz phenocrysts. The felsic unit is overlain by a massive basaltic flow, which at its base contains several elipsoidal fragments up to 15 cm long composed of the underlying rhyolite.

About 80 m below the felsic flow is about 3 m of felsic lapilli-tuff consisting of about 70 percent subangular lapilli and coarse ash of pink weathering rhyodacite to rhyolite with scattered mafic lapilli. The matrix is composed of poorly sorted volcanic debris cemented by hydrothermal quartz and feldspar.

These felsic units are apparently extensions of more numerous felsic flows shown on detailed geological maps of Amax Explorations Limited which cover

an area just east of the current map-area (see Resident Geologist's Files, Ontario Ministry of Natural Resources, Sault Ste. Marie). The increase in felsic volcanic rocks in the eastern end of the belt suggests the presence of a volcanic centre in that area.

## *METASEDIMENTS*

### *Clastic Rocks*

Sedimentary rocks form a very minor part of the Thessalon Formation in the map-area, and are for the most part found as thin units confined to the lowermost 100 m of the volcanic sequence. In spite of their limited distribution in outcrop, the clastic sedimentary rocks are significant. This is because they contain some uraniferous quartz-pebble conglomerate beds which may indicate similar depositional conditions, if not a direct chronological and stratigraphic correlation with the major uranium deposits of the Elliot Lake area.

Clastic sedimentary units interbedded with the volcanic flows of the Thessalon Formation are from 1 to 5 m thick. The usual lithologies found are dark grey wacke and siltstone overlain by a pale, coarse-grained arkose and subarkose.

Sedimentary rock units found within the Thessalon Formation are typically medium sand- to grit-sized, poorly sorted, subarkose, and arkose. The weathered surfaces are generally pale grey. Freshly broken surfaces are characterized by pink, potassium feldspar grains set among dark grey, glassy, quartz grains.

In places, the arenite units contain widely scattered quartz pebbles up to 2 cm across. Grit beds locally contain a high proportion of pink potassium feldspar grains up to 1 cm long which retain an almost euhedral crystal form. This gives the rock the appearance of a siliceous, porphyritic granite.

Bedding in the arenite is poorly defined, but low-angle planar crossbeds are evident in a few outcrops.

A volcanic quartz-pebble conglomerate which outcrops as a 1 m thick unit below the coarse arkose unit, consists of about 40 percent subrounded to subangular small pebbles to large cobbles of mafic metavolcanics (in part amygdaloidal) megascopically identical to the enclosing Thessalon volcanic rocks. Very angular to subrounded quartz pebbles amount to 15 percent of the rock, and are set in a matrix of poorly sorted sand- and grit-sized pink feldspar and quartz similar to that of the sandstone-grit units.

The volcanic quartz-pebble conglomerate is slightly radioactive (about 2 times background). A similar unit intersected in diamond-drill core by Rio Algom Limited at the eastern end of the volcanic belt, is reported to contain trace uranium (Regional Geologist's Files, Ontario Ministry of Natural Resources, Sault Ste. Marie).

The volcanic quartz-pebble conglomerate is essentially a quartz-pebble conglomerate diluted by the local volcanic debris.

Because of their thinness and the scattered outcrop distribution, the sedi-

TABLE 3 | CHEMICAL ANALYSES OF TWO SAMPLES OF SILTSTONE FROM THESSALON FORMATION, TWO HORSE LAKE*

| Major Components in Weight Percent | | |
|---|---|---|
| Field Number | B8-5 | W10-8 |
| $SiO_2$ | 49.7 | 60.1 |
| $Al_2O_3$ | 14.0 | 16.6 |
| $Fe_2O_3$ | 4.14 | 2.02 |
| FeO | 2.38 | 5.11 |
| MgO | 0.93 | 3.49 |
| CaO | 8.93 | 0.97 |
| $Na_2O$ | 0.05 | 5.23 |
| $K_2O$ | 3.45 | 2.13 |
| $H_2O+$ | 0.59 | 2.12 |
| $H_2O-$ | 0.22 | 0.35 |
| $CO_2$ | 0.22 | 0.13 |
| $TiO_2$ | 0.71 | 0.72 |
| $P_2O_5$ | 0.06 | 0.17 |
| S | 0.01 | 0.02 |
| MnO | 0.05 | 0.06 |
| TOTAL | 98.8 | 99.2 |

Location of Samples

W10 - 460 m west of McMahon Lake, 100 m south of northern boundary of Aberdeen Township.

W8 - 5 690 m northeast of and southeast of Bass Lake.

* Chemical analyses by Geoscience Laboratories, Ontario Geological Survey.

mentary units near the base of the volcanic assemblage could not be traced along strike as a continuous unit.

In thin section, the dark siltstone and wacke intercalated with the metavolcanics of the Thessalon Formation are seen to contain a significant proportion (2 to 10 percent by visual estimate) of angular to well rounded quartz, plagioclase, and microcline which are up to 0.5 mm across. These minerals could not have been derived from the volcanic rocks, and almost certainly have a granitic provenance. The fine-grained sericitic and chloritic matrix on the other hand, contains much fine-grained leucoxene and opaque minerals which in part may represent a volcanic contribution.

Two chemical analyses of fine-grained wacke and siltstone are given in Table 3.

The interflow arkose and quartz-pebble conglomerate beds near the base of the Thessalon Formation in Aberdeen Township, about 1 km east of the map-

area, are similar in most respects to those near the base of the Thessalon Formation in the Sault Ste. Marie and Thessalon areas (Bennett 1976, 1977). Sedimentary units are thin; usually less than 1 m thick. Radioactivity is restricted to the quartz-pebble conglomerate and invariably attains background only in the arkosic sections. There is abundant pink potassium feldspar in the arkose and most of the conglomerate beds. The feldspar is up to 1 cm long, commonly angular, and has primary crystal forms. Quartz is well rounded to angular and up to 5 cm across. Pyrite is a common minor constituent and is locally present up to 5 percent. The matrix is dark grey, black, or hematitic in many of the more radioactive beds. The presence of red hematite, not the usual hydrous iron oxides, in the more radioactive beds, was not noted in the Sault Ste. Marie or Thessalon areas, and may be significant.

## *PETROCHEMISTRY*

Tables 4 and 5 show whole rock chemical analyses for 15 samples of volcanic rock of the Thessalon Formation collected during the current survey along with two analyses from F.W. Chandler (1973).

Figures 2 and 3 give the chemical classification of these volcanic rock analyses according to the schemes of T.N. Irvine and W.R.A. Baragar (1971) and L.S. Jensen (1976). The Jensen Cation Plot, (Figure 3), places all samples except one in the tholeiitic field, but the method of Irvine and Baragar (1971) suggests the presence of more calc-alkaline rocks. The author considers the Jensen plot to be more reliable as a classification aid to metamorphosed volcanic rocks, since it places less weight on the "mobile" alkali elements. Figure 4, an alkali ratio plot, is an "igneous spectrum" plot as suggested by C.J. Hughes (1973). Points outside the boundary lines which enclose the range of alkali ratios found in unaltered volcanic rocks, are believed to indicate post-volcanic metasomatism. This has resulted in a disturbance of the original alkali ratios. The alkali ratios of most samples from the Thessalon Formation of Aberdeen Township fall within the igneous spectrum. A few, however, fall well outside the igneous field, and suggest some local alteration of bulk rock composition has occurred.

Figure 5 illustrates the variation of some minor "immobile" elements with stratigraphic height in the volcanic belt measured as a horizontal distance upsection. The figure shows that the analyzed samples can be divided into two groups. Samples from below about 400 m above the base of the formation (about 1067 m horizontal distance) are significantly richer in titanium and phosphorous and are for the most part lower in chromium and nickel than samples more than 400 m above the base of the formation. Chromium appears to be a particularly sensitive element, emphasizing the variation in magnesium content.

The plots on the Jensen diagram were examined in terms of stratigraphic height. It was found that samples from the upper half of the volcanic belt fall on the more magnesian side of the curve a-a on Figure 3, and that the samples from the lower half of the belt plot on the aluminium side. This indicates that the Bass Volcanic Belt of the Thessalon Formation can be divided on the basis

TABLE 4 CHEMICAL ANALYSES OF BASALT (UPPER UNIT) OF THE THESSALON FORMATION ANALYSES, TWO HORSE LAKE AREA*.

Major Components in Weight Percent

| Sample Number | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Average |
|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 48.6 | 49.3 | 50.5 | 49.0 | 51.5 | 49.7 | 53.8 | 50.3 |
| $Al_2O_3$ | 15.1 | 15.4 | 14.0 | 15.4 | 13.5 | 14.0 | 15.6 | 14.7 |
| $Fe_2O_3$ | 2.30 | 1.90 | 2.60 | 3.60 | 3.30 | 2.10 | 1.80 | 2.51 |
| FeO | 10.0 | 10.5 | 11.3 | 9.27 | 10.5 | 11.7 | 9.25 | 10.4 |
| MgO | 7.09 | 7.15 | 5.55 | 6.91 | 4.39 | 5.75 | 5.66 | 6.07 |
| CaO | 9.64 | 8.05 | 7.01 | 7.22 | 8.43 | 7.59 | 4.36 | 8.18 |
| $Na_2O$ | 2.20 | 2.52 | 3.62 | 2.56 | 2.90 | 3.22 | 3.81 | 2.97 |
| $K_2O$ | 0.13 | 0.39 | 0.42 | 0.38 | 0.20 | 0.85 | 0.40 | 0.99 |
| $H_2O+$ | 2.36 | 2.62 | 2.60 | 3.65 | 1.89 | 2.39 | 3.25 | 2.68 |
| $CO_2$ | 0.60 | 0.12 | 0.35 | 0.46 | 0.20 | 0.14 | 0.34 | 0.31 |
| $TiO_2$ | 0.84 | 0.95 | 1.14 | 0.88 | 1.20 | 1.11 | 0.82 | 0.99 |
| $P_2O_5$ | 0.09 | 0.12 | 0.14 | 0.11 | 0.19 | 0.17 | 0.12 | 0.13 |
| S | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | — |
| MnO | 0.19 | 0.21 | 0.22 | 0.16 | 0.21 | 0.23 | 0.14 | — |
| TOTAL | 99.4 | 99.5 | 99.8 | 99.9 | 98.9 | 99.2 | 99.7 | — |

Trace Elements in parts per million (ppm)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ba | 120 | 260 | 300 | 140 | 70 | 510 | 100 | — |
| Co | 50 | 55 | 55 | 50 | 50 | 55 | 45 | — |
| Cr | 160 | 165 | 75 | 180 | 45 | 85 | 150 | 123 |
| Cu | 130 | 110 | 180 | 120 | 130 | 155 | 65 | — |
| Ga | — | — | — | — | 15 | 15 | 10 | — |
| Li | 20 | 20 | 20 | — | 5 | 10 | 10 | — |
| Ni | 105 | 120 | 80 | 135 | 60 | 75 | 95 | 76 |
| Pb | 15 | 20 | 20 | 15 | 10 | 10 | 80 | — |
| Sc | — | — | — | — | 45 | 40 | 40 | — |
| Sn | — | — | — | — | 4 | 3 | 3 | — |
| Sr | — | — | — | — | 300 | 200 | 200 | — |
| Zn | 105 | 115 | 130 | 120 | 110 | 125 | 90 | — |

Location of Samples: All samples are from Aberdeen Township.

* Chemical analyses by Geoscience Laboratories, Ontario Geological Survey.

TABLE 5 CHEMICAL ANALYSES OF BASALTIC ANDESITE (LOWER UNIT) OF THE THESSALON FORMATION, TWO HORSE LAKE AREA.*

Major Components in Weight Percent

| Sample Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Average | |
|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 51.6 | 58.6 | 50.8 | 52.4 | 55.1 | 56.1 | 53.9 | 50.1 | 53.5 | |
| $Al_2O_3$ | 14.1 | 13.3 | 14.5 | 13.4 | 13.5 | 13.7 | 13.8 | 14.5 | 13.8 | |
| $Fe_2O_3$ | 1.50 | 5.32 | 2.90 | 4.10 | 4.37 | 4.78 | 2.10 | 4.20 | 3.65 | |
| FeO | 10.1 | 5.38 | 10.8 | 9.66 | 8.40 | 6.23 | 10.9 | 9.84 | 8.91 | |
| MgO | 5.00 | 2.22 | 4.04 | 3.57 | 3.13 | 2.76 | 4.06 | 4.11 | 3.61 | |
| CaO | 6.16 | 4.56 | 5.56 | 5.68 | 5.62 | 7.24 | 4.72 | 6.55 | 5.76 | |
| $Na_2O$ | 3.73 | 6.03 | 4.31 | 3.20 | 2.82 | 3.39 | 4.43 | 3.69 | 3.95 | |
| $K_2O$ | 1.98 | 0.44 | 1.19 | 1.68 | 1.00 | 0.98 | 0.96 | 0.91 | 1.13 | |
| $H_2O+$ | 2.16 | 0.96 | 2.54 | 2.20 | 2.52 | 1.39 | 2.21 | 2.51 | 2.06 | |
| $CO_2$ | 0.12 | 0.11 | 0.26 | 0.59 | 0.27 | 0.12 | 0.13 | 0.45 | 0.25 | |
| $TiO_2$ | 1.90 | 1.20 | 1.91 | 1.76 | 1.58 | 1.63 | 1.71 | 1.81 | 1.68 | |
| $P_2O_5$ | 0.35 | 0.16 | 0.35 | 0.32 | 0.26 | 0.40 | 0.28 | 0.33 | 0.31 | |
| S | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | | |
| MnO | 0.15 | 0.22 | 0.16 | 0.20 | 0.18 | 0.14 | 0.15 | 0.19 | 22 | |
| TOTAL | 99.2 | 99.3 | 99.6 | 99.5 | 99.3 | 99.4 | 99.6 | 99.6 | 38 | |

Trace Elements in parts per million (ppm)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ba | 940 | 100 | 420 | 610 | 210 | 200 | 190 | 200 | |
| Co | 45 | 35 | 50 | 45 | 50 | 35 | 50 | 55 | |
| Cr | 110 | 5 | 15 | 5 | 5 | 10 | 10 | 15 | 22 |
| Cu | 110 | 95 | 185 | 140 | 195 | 250 | 50 | 85 | |
| Ga | 15 | 10 | — | 15 | 15 | 15 | 10 | — | |
| Li | 15 | 3 | 15 | 10 | 15 | 10 | 10 | — | |
| Ni | 90 | 20 | 70 | 25 | 30 | 15 | 40 | 50 | |
| Pb | 10 | 10 | 15 | 10 | 20 | 40 | 10 | 20 | |
| Sc | 20 | 45 | — | 30 | 30 | 35 | 30 | -- | |
| Sn | 3 | 5 | — | 4 | 4 | 4 | 3 | — | |
| Sr | 400 | 300 | — | 500 | 500 | 800 | 200 | -- | |
| Zn | 125 | 90 | 130 | 125 | 130 | 80 | 150 | 130 | |

Location of Samples: All samples are from Aberdeen Township.

* Chemical analyses by Geoscience Laboratories, Ontario Geological Survey.

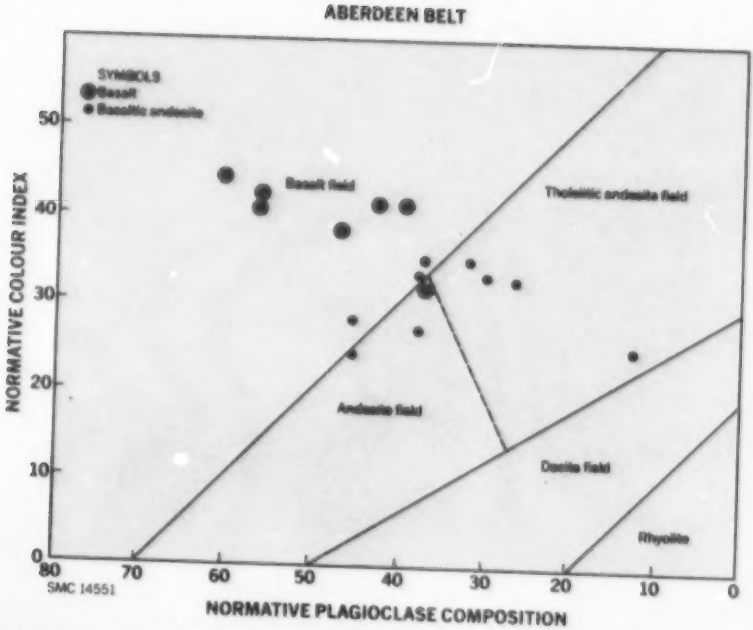



Figure 2–Normative colour index versus normative plagioclase composition plots for volcanic rocks of the Thessalon Formation, Two Horse Lake Area (after Irvine and Baragar 1971).

of chemical composition into an upper tholeiitic basalt and a lower, tholeiitic basalt-andesite series.

## *SUMMARY*

The scarcity of pillow structures and the apparent absence of hyaloclastite indicates the flows were extruded under essentially subaerial conditions where standing bodies of water were of short duration and extent. Presumably, active flows would quickly fill existing depressions and displace any water present.

The coarsest sedimentary rocks within the volcanic succession are quartz-pebble conglomerate and coarse-grained arkose derived from continental detritus. This suggests volcanic rocks may have occupied a depression which periodically received cratonic debris.

The geological setting and the physical and chemical characteristics of the Huronian metavolcanics of the Two Horse Lake Area indicate that these rocks belong to a continental flood basalt province similar in many respects to the younger, Late Precambrian Keweenawan flood basalts of the Lake Superior Basin located to the west. The Huronian basaltic magmas may have risen

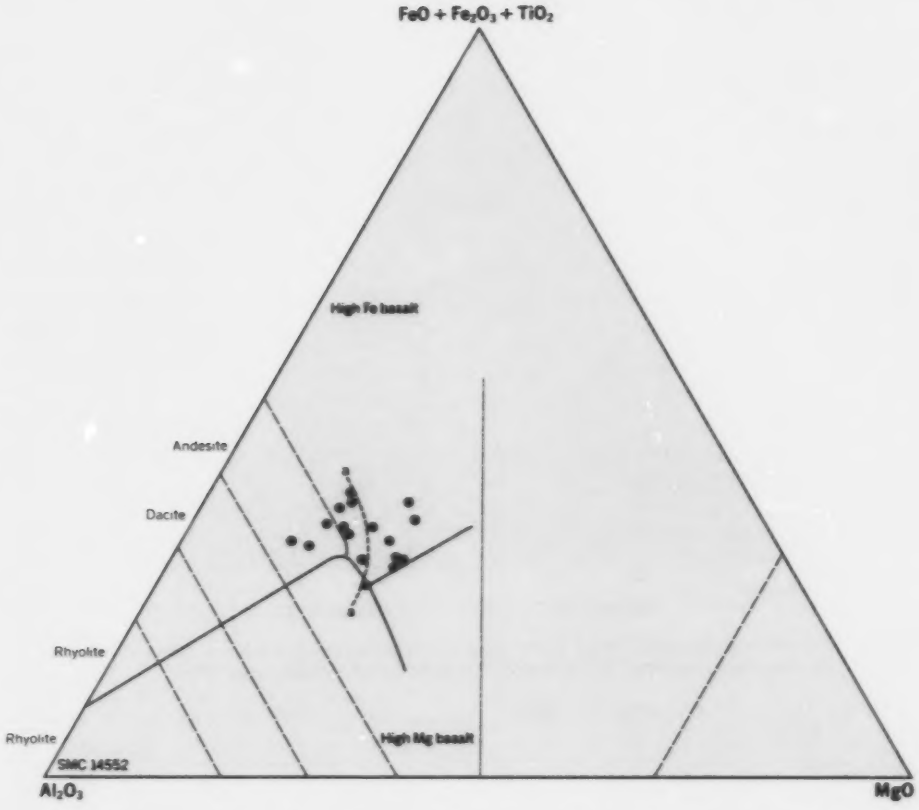



Figure 3–Jensen Cation plot of volcanic plot of volcanic rocks of the Thessalon Formation, Aberdeen and McMahon Townships.

through the crust along a fundamental zone of crustal weakness extending westward from the present Gulf of St. Laurence (Kumarapeli and Saul 1966). D.G. Innes (1977) suggested that the Huronian volcanic rocks along the North Shore of Lake Huron were erupted along an intracratonic rift.

The volcanic rocks of the Thessalon Formation in the Sault Ste. Marie area contain near the base, very coarse grained arkose units with uraniferous quartz-pebble conglomerate beds. These rocks are lithologically similar, if not identical to the coarse arkose and subarkose units of Aberdeen Township described above.

Similarly, the Livingstone Creek Formation in the Sault Ste. Marie area is likewise lithologically identifiable with that of Aberdeen Township (Frarey 1975).

In the Thessalon area, similar correlations can be proposed on the basis of

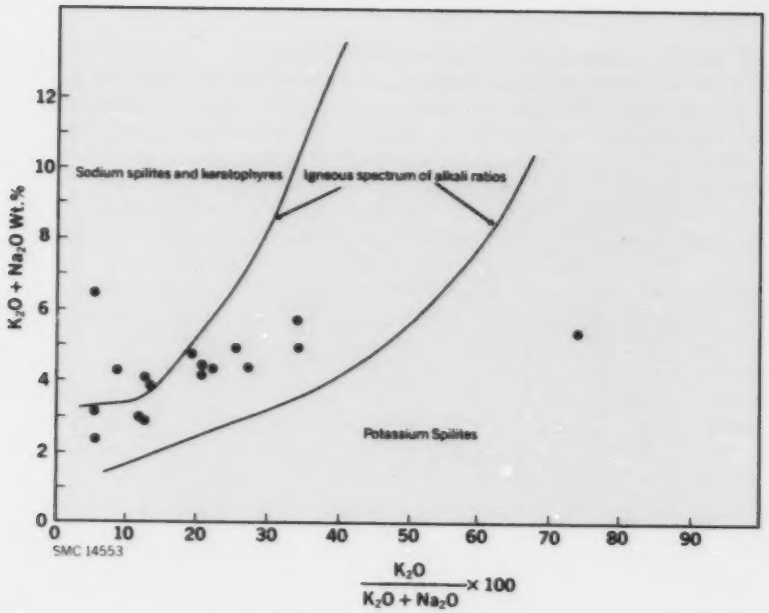



Figure 4–Alkali ratios of volcanic rocks of the Thessalon Formation, Aberdeen and McMahon Townships.

lithology, but there, the very coarse grained arkose beds, again associated with uraniferous quartz-pebble conglomerate, are found in part to be immediately below the metavolcanics, but directly above the well-sorted sandstones of the Livingstone Creek Formation (Bennett 1976).

Chandler (1973) correlated the basal sandstones of Morin and Otter Townships with the Matinenda Formation. Examination of these sandstones by the author in 1976 and 1978 indicated that the lowermost grey sandstone and granite-cobble conglomerate is equivalent to the Livingstone Creek Formation. The Livingstone Creek Formation of Morin and Otter Townships is unconformably overlain by a greenish, sericitic sandstone and uraniferous, quartz-pebble conglomerate of the Matinenda Formation. Clear evidence of the unconformable relationship between the Livingstone Creek Formation and the Matinenda Formation can be seen near the crest of a hill about 400 m south of the north boundary of Haughton Township, and about 400 m east of the main lumber haulage road. Here pyritic, quartz-pebble conglomerate (non-radioactive) of the Matinenda Formation overlies fine-grained, crossbedded sandstones of the Livingstone Creek Formation. For about 2 m below the base of the Matinenda Formation, the Livingstone Creek sandstones are tinted a distinct apple-green, a typical colour of the Matinenda Formation. This green colouration, which is atypical of the Livingstone Creek Formation, passes gradation-

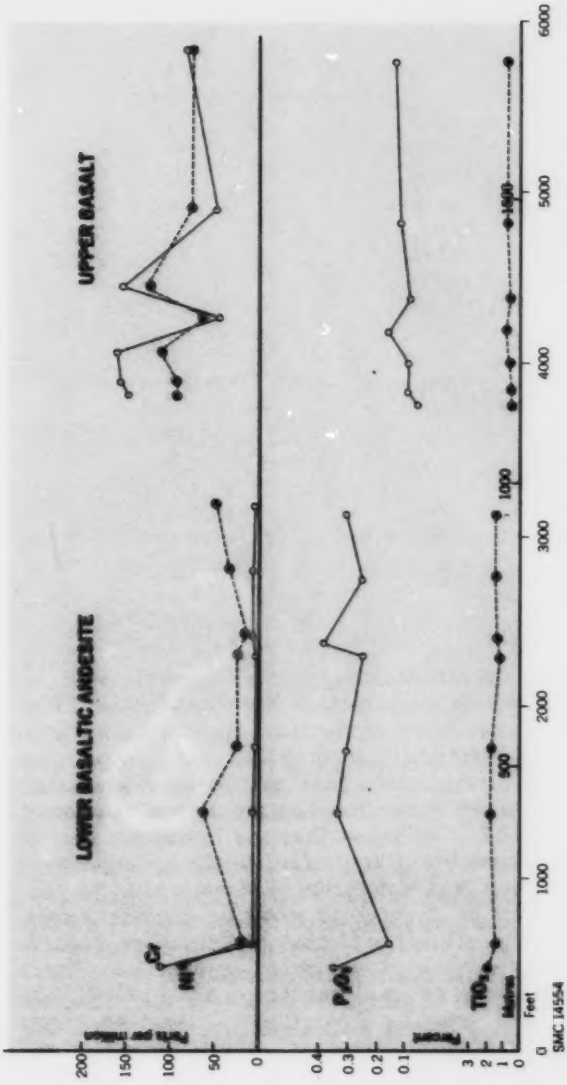



Figure 5–Variation of some minor elements with stratigraphic height in the Thesson Formation, Aberdeen Township.

ally into the normal, drab, grey sandstones of the Livingstone Creek Formation. The most reasonable interpretation is that the green (sericite) colouration of the Livingstone Creek Formation represents a regolith. This regolith along with the abrupt change in grain size, sorting, and composition between the Matinenda and Livingstone Creek Formations, suggests that a significant period of erosion preceded the deposition of the Matinenda Formation. Since the stratigraphic position of this regolith is also that of the Thessalon Formation, much of the Thessalon Formation may also have been removed during this period of weathering.

In 1968, Imperial Oil Limited, W.D. Sutherland and Kerr-McGee Corporation drilled several deep diamond-drill holes in Galbraith and Haughton Townships which lie east of the current map-area. Drill logs in the assessment files of the Regional Geologist at Sault Ste. Marie indicate the subsurface extension of Huronian volcanic rocks up to 16 km east of the Aberdeen Volcanic Belt. The volcanic rocks thin to less than 60 m in thickness in south-central Haughton Township (Kerr-McGee hole HA-1) and are absent in east-central Haughton Township (Imperial Oil hole 68-7), (see Resident Geologist's Files, Ontario Ministry of Natural Resources, Sault Ste. Marie).

The drill logs indicate as much as 430 m of a fine-grained, grey sandstone was intersected below the volcanic rocks. Selected core specimens from some of these holes are stored in the drill core storage depot of the Ontario Ministry of Natural Resources at Sault Ste. Marie. Examination of these core samples and the available diamond drill-hole data makes it certain that the grey sandstone below the volcanic rocks of Haughton and Galbraith Townships is the Livingstone Creek Formation.

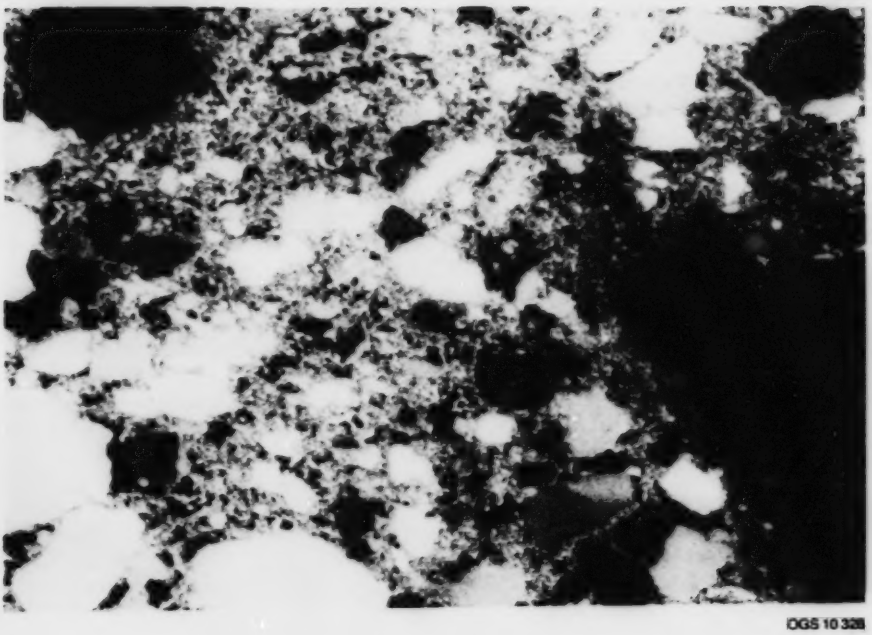
The Thessalon and Livingstone Creek Formations of Haughton Township are only about 16 km north of the Thessalon Volcanic Belt (Frarey 1975; Bennett 1976). It is likely, therefore, that the Thessalon Formation and the Livingstone Creek Formation are laterally continuous in the subsurface between Haughton and Thessalon Townships.

## HOUGH LAKE GROUP

### Ramsay Lake Formation

Outcrops of massive, siliceous, matrix-supported conglomerate on the east and west shores of Bass Lake and north of Hart Lake near Coffee Creek, have been assigned to the Ramsay Lake Formation (Frarey 1975). At the east end of Bass Lake, a unit of grey, fine-grained wacke underlies the conglomerate, but elsewhere, the base of the conglomerate is not exposed. North of Hart Lake, the Ramsay Lake conglomerate was seen to pass upwards into pink subarkose of the Mississagi Formation. The uppermost 1 to 2 m of the Ramsay Lake Formation has a greenish grey, less siliceous, wacke matrix. There is no evidence of an erosional unconformity or basal conglomerate in the Mississagi Formation; nor is there any siltstone correlative to the Pecors Formation.

The generally poor exposure along the valley of Coffee Creek prevents any



OGS 10 328

Photo 1–Photomicrograph of the matrix of the Ramsay Lake Formation (approximately x25). Large dark clast is chloritized mafic volcanic. Note the angularity of many of the quartz grains. The grey matrix is very fine grained white mica.

estimate of the thickness of the Ramsay Lake Formation in the map-area. The outcrops at the eastern end of Bass Lake suggest that the formation there is at least 30 m thick.

About 1.6 km southeast of the southeast corner of the map-area, detailed mapping by Amax Explorations Limited found a conglomerate which they considered to be Ramsay Lake Formation lying directly upon the metavolcanics of the Thessalon Formation. A diamond-drill hole (ABA-69-1) about 0.8 km north of the conglomerate outcrops, however, intersected about 107 m of Matinenda sandstone between the Thessalon and the Ramsay Lake Formations (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sault Ste. Marie).

The diamond-drill hole, AXB 69-1, intersected 21.3 m (core length) of Ramsay Lake type conglomerate overlying 10.5 m of greywacke (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sault Ste. Marie).

Within the map-area, the Ramsay Lake Formation consists mainly of polymictic conglomerate with angular to subrounded pebbles and cobbles of chloritic mafic metavolcanics, grey, massive, and foliated granitic clasts, and well rounded pebbles of quartz. These clasts are supported by an abundant matrix of medium to coarse sand-sized quartz and subordinate feldspar, labile clasts and pyrite (Photo 1).

TABLE 6 MEGACLAST LITHOLOGIES IN THE RAMSAY LAKE FORMATION,[1] TWO HORSE LAKE AREA.

| | % of area | mean size (cm) | % of area | mean size (cm) | % of area | mean size (cm) | % of area | mean size (cm) | % of area | mean size (cm) |
|---|---|---|---|---|---|---|---|---|---|---|
| Matrix | 75 | — | 60 | — | 10 | — | 75 | — | 85 | — |
| Volcanic | 20 | 8 | 25 | 10 | 65 | 20 | 15 | 5 | 10 | 3 |
| Granitic massive | 4 | 3 | 10 | — | 23 | 3 | 10 | 4 | 4 | 2 |
| Granitic gneissic | 0 | — | 5 | — | 0 | — | 0 | — | 0 | — |
| Quartz | 1 | 3 | 0 | — | 1 | — | 0 | — | 1 | 3 |
| Location | | 1 | 1 | | 1 | | 2 | | 2 | |

[1]Visual estimate over 1 $m^2$.

Location 1 - Southeast shore of Bass Lake, Aberdeen Tp.

Location 2 - 1 km north of Hart Lake, Aberdeen Add'l Tp.

Clasts of mafic volcanic rocks and grey or white granite in a siliceous sandy matrix are generally considered to be characteristic features of the Ramsay Lake Formation. Tables 6 and 7 give the estimated megaclast content and measured modes of the matrix of Ramsay Lake conglomerate.

### Mississagi Formation

The Mississagi Formation forms a broad, northwest-trending band from Bass Lake, through Echo Lake to the western border of the map-area (Frarey 1975). The lower contact of the formation is poorly defined and is probably a fault over much of its length. Nevertheless, the thickest section exposed in southeast Kehoe Township, comprises as much as 1500 m, and consists almost entirely of sandstone. The presence of the easily recognizable Espanola Formation at Echo Lake and at Two Horse Lake, makes for an unequivocal correlation of these sandstones with the Mississagi Formation of other areas along the North Shore of Lake Huron.

Sandstones of the upper half of the Mississagi Formation are predominately pale pink to pale grey, medium- to coarse-grained, moderately well-sorted subarkose. The sandstones of the lower half of the formation tend to be darker grey and finer grained, although numerous exceptions to this occur. A characteristic of the Mississagi Formation of the map-area is a well-developed

TABLE 7 MODAL ANALYSES OF PARACONGLOMERATE MATRICES, TWO HORSE LAKE AREA.

| Field Number | B34-6 | B6-9 | B6-2 | B50-7 |
|---|---|---|---|---|
| Quartz | 39 | 21.2 | 13.4 | 17.9 |
| Feldspar | | | | |
| Plagioclase | 1 | 3.4 | 7.2 | 1.4 |
| Potassic Feldspar | | 2.4 | 1.0 | 0.1 |
| Granitic fragments | 0.2 | 1.6 | 14.8 | 1.6 |
| Labile fragments | | | | |
| Mafic volcanic, Diabase | 8 | | 5 | |
| Siltstone | | | 22 | |
| Matrix | | | | |
| Sericite | 48 | 64 | | |
| Sericite-chlorite | | | 36 | |
| Pyrite | 4 | | | |
| Carbonate | | | | |
| Quartz + chlorite + magnetite | | | 1 | 79.0 |

Samples

B34-6 Ramsay Lake Formation
B6-9 Sheared Gowganda Formation
B6-2 Gowganda Formation
B50-7 Bruce Formation

planar crossbedding with coset thicknesses of about 1 m. Beds are rarely as thick as 3 m or as thin as 0.5 m. Cosets are usually defined by thin partings or laminae of very fine grained, yellowish green sericitic wacke which locally display well developed ripple marks.

The sandstones consist mainly of subangular to rounded quartz (60-80 percent), plagioclase (1-13 percent), potassic feldspar (4-13 percent), and subordinate lithic clasts in a usually sparse matrix of very fine quartz, feldspar, and sericite. Very minor amounts of biotite, stilpnomelane, chlorite, and zircon, have been identified in thin sections of the Mississagi Formation. Modal analyses of three specimens of sandstones of the Mississagi Formation are given in Table 8.

Beds of grit and quartz-pebble conglomerate are present in a few places, notably about 2500 m northwest of Haversack Lake. The coarser beds contain small pebbles of pink to red jasper and black chert, closely resembling some units in the Lorrain Formation.

TABLE 8 MODAL ANALYSES OF SANDSTONES OF THE MISSISSAGI FORMATION, TWO HORSE LAKE AREA.

| Major Components | 1 | 2 | 3 |
|---|---|---|---|
| Quartz | 68.5 | 78.9 | 76.0 |
| Plagioclase | 0.6 | 13.3 | 8.2 |
| Potassic feldspar | 13.6 | 4.2 | 2.8 |
| Rock Fragments | | | |
| "Granite" | 6.5 | | 2.0 |
| "Quartzite" | | | |
| Matrix (0.05 mm) | 10.8 | 3.6 | 11.0 |
| | 100.0 | 100.0 | 100.0 |

Location of Samples

1. Subarkose, Kehoe Township.
2. Subarkose, Kehoe Township.
3. Subarkose, Kehoe Township.

On the hill overlooking the northwest shore of Echo Lake, there are a few units of foliated, dark grey, greenish grey and brownish grey wacke up to 30 m thick. Bedding within the wacke units is poorly developed.

Thin units of polymictic matrix-supported conglomerate are also found within pale grey subarkose of the Mississagi Formation near the northwest shore of Echo Lake and about 1200 m east of the northeast end of Echo Lake. The conglomerate is not well exposed and appears to be only a few metres thick. At both occurrences, the phenoclasts are rounded pebbles of pink and grey granitic rocks and flattened fine-grained chloritic volcanic clasts with a few quartz pebbles. The matrix is a dark grey subarkose to subwacke which forms about 70 percent of the rock. A bed of grey subarkose about 1 m thick is found within the conglomerate occurring east of the lake.

These conglomerates have been correlated with similar rocks identified by Chandler (1973) near the base of the Mississagi Formation northeast of the current map-area. It does not appear likely that the conglomerates are an attenuated extension of the Ramsay Lake Formation, the nearest known outcrop of which is about 8 km to the southeast. Although the conglomerates in question bear some textural and lithological similarity to the Ramsay Lake Formation, the presence of sandstone interbeds is atypical of the Ramsay Lake Formation. Immediately above and below the conglomerates are lithologically similar sandstones suggesting that the conglomerates are interbedded with the Mississagi Formation. Diamond-drill holes by Gulf Minerals Canada Limited (Resident Geologist's Files, Sault Ste. Marie, log by E.J. Leahy), intersected no conglomerates before intersecting the faulted base of the Mississagi Formation, thus indicating that the Ramsay Lake Formation is faulted out in the area.

## QUIRKE LAKE GROUP

### Bruce Formation

Polymictic clast-supported conglomerates identified as Bruce Formation were found at only three localities in the map-area. At each locality the stratigraphic relationships and lithologies are sufficiently distinctive to allow a positive identification.

An outcrop of pebbly wacke and crudely laminated pyritiferous and calcareous siltstone of the Bruce Formation is located about 30 m north of and apparently underlies an outcrop of Espanola Limestone about 600 m east of Two Horse Lake.

Many scattered blocks of polymictic conglomerate and pale grey siltstone were found along the northwest side of a hill which forms the east shore of Echo Lake northeast of Marble Point. The float is found along a zone between outcrops of Mississagi Formation near the road lower on the hill and outcrops of Espanola Formation which form the ridge. A search along the hill has shown that the conglomerate float almost certainly reflects the underlying bedrock which should be Bruce Formation. The distribution of float suggests Bruce conglomerate in the area is about 3 to 6 m thick and overlain by about an equal thickness of massive and finely laminated siltstone.

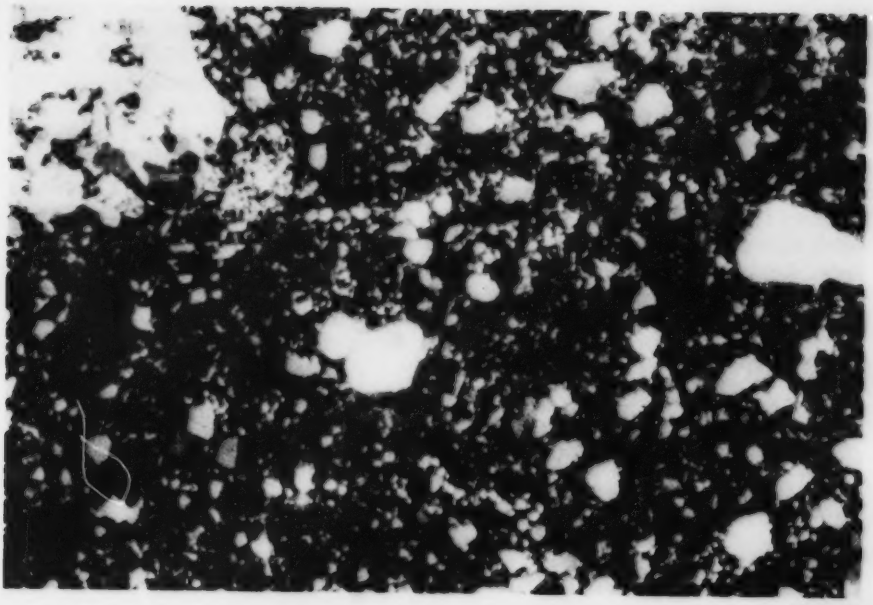
The conglomerate is mainly sparse pebble and cobble, matrix-supported, polymictic conglomerate with grey granitic clasts predominant, with lesser amounts of dark green chips of mafic rock (probably Huronian metabasalt). The matrix is a medium grey wacke with sand-sized quartz, feldspar, and locally 1 to 2 percent pyrite (Photo 2).

A 3 to 4 m thick unit of massive, matrix-supported conglomerate conformably overlies sandstone of the Mississagi Formation near the boundary of Indian Reserve Number 14 west of Echo Lake. Pebbles to large cobbles of white granitic rocks and brownish weathering, flattened pebbles of Huronian metavolcanics are supported by an abundant grey quartz-rich matrix containing angular clasts of pyrite up to 5 mm long (Photo 3).

The lower contact of the conglomerate is sharp and concordant with bedding in the underlying Mississagi Formation. The conglomerate is conformably overlain by at least 9 m of pyritiferous siltstone which is thin bedded at the base and passes up to a delicately laminated unit with laminations from less than a mm up to 2 cm thick. The laminated siltstone closely resembles some Pleistocene varved sequences. Pyrite nodules up to 2 cm across occur at intervals from 2 to 10 cm along some individual laminations within the siltstone.

The Espanola Formation was not identified at the above location; instead, siltstone and conglomerate of the Gowganda Formation probably directly overlie the siltstone of the Bruce Formation.

In thin section, the matrix of the Bruce conglomerate is seen to consist of medium to coarse sand-sized quartz and lithic fragments in a submatrix of fine sand-sized quartz, feldspar, chlorite, fine needles of rutile, and up to 2 percent rounded to octahedral crystals of magnetite less than 0.1 mm across. Sulphides were not noted in thin sections, probably because of the tendency for sulphides



OGS 10 329

Photo 2–Matrix of Bruce Formation, Kehoe Township (approximately x 15).

OGS 10 330

Photo 3–Bruce Formation, matrix-supported, polymictic conglomerate on a hill just west of Echo Lake, Kehoe Township. Dark clasts are volcanic, speckled clasts are grey granitic rocks, large clast near pencil is quartz.

to occur as dispersed nodules (see Table 7). The matrix of the Bruce conglomerate resembles the Ramsay Lake Formation conglomerate in that it has a high proportion of sand-sized quartz and locally conspicuous pyrite (see Photo 2), but it differs from the Ramsay Lake conglomerate in that it contains chlorite in place of sericite. The Gowganda Formation generally contains a greater variety of clasts than either the Ramsay Lake or Bruce conglomerates. The matrix contains both sericite and chlorite and generally little pyrite (see Table 7).

In summary, the Bruce Formation, where observed within the map-area, is no more than and generally less than 15 m thick, consisting of approximately equal thicknesses of basal, polymictic, matrix-supported conglomerate and an upper laminated pyritiferous and locally calcareous siltstone. Similar internal stratigraphy has been described by Robertson (1964, p.33) in the Bruce Formation in Cobden, Scarfe, and Striker Townships north of Blind River.

## Espanola Formation

### *LIMESTONE*

The Bruce Limestone member of the Espanola Formation is the only significant limestone unit within the Huronian succession of the North Shore of Lake Huron. As such, and especially in view of its ubiquitous and characteristic differentially weathered surface, it is the most reliable and usefull stratigraphic marker within the map-area.

The Espanola Formation is sparsely represented within the map-area. The best exposures are at Marble Point on the east shore of Echo Lake and on a similar promontory on the west shore of the lake.

The Espanola Formation consists mainly of characteristic interlaminated grey limey siltstone and pale grey to pale pink and buff granular limestone. A unit of dark grey massive and finely laminated chert up to 3 m thick is interbedded with Espanola limestone near the waterline on the north side of Marble Point.

The poor exposure and highly deformed nature of the Espanola Formation in the area precludes an accurate estimate of its true thickness. At Marble Point, the Espanola Formation is probably in the order of 30 m thick.

### *SKARN DEPOSITS*

Between Hart Lake and Two Horse Lake, the Espanola Formation has been intruded by a thick sill-like body of Nipissing gabbro. Along the contact between the limestone and the gabbro, the Espanola Formation has been converted to a dense, massive to laminated, dark rock bearing variable amounts of dark green amphibole, brown garnet, magnetite, carbonate, and chalcopyrite. All stages in the development of garnet and amphibole-rich skarn from laminated siltstone and calcite beds can be seen in outcrops about 300 m west of

Hart Lake. Dark green to black, coarse, stubby amphibole is initially developed as thin lenses along silty laminae and continues until the silty limestone is completely replaced by dark skarn in which alternating beds of amphibole and garnet reflect perfectly the primary structures of the Espanola Formation.

The skarn is best developed on the west contact of the Nipissing gabbro near the southeast end of Two Horse Lake where concentrations of magnetite and chalcopyrite associated with the skarn have been the object of mineral exploration (see section on "Safari Exploration Limited [1974] (11)" and F. Guillemette, P. Laverdiere, and L.A. Laframboise (5))[1].

In 1966, thin seams of magnetite and a few blebs of chalcopyrite were found in an outcrop of skarn about 30 m west of Hart Lake.

Two thin sections of the skarn were examined. One consisted almost entirely of tightly interlocking, stubby, amphibole crystals about 1 mm long exhibiting pleochroism from dark blue green to pale brown. Minor amounts of calcite fill the interstices.

The remaining thin section was found to consist mainly of about equal amounts of bluish green amphibole, and poorly crystallized yellowish garnet; epidote, carbonate, and idocrase are present in minor amounts.

## COBALT GROUP

### Gowganda Formation

The Gowganda Formation is represented in the map-area by thick clastic sequences which are located mainly in northwest Kehoe Township, along Cuddy Creek in Chesley Additional Township and northwest from the south shore of Bass Lake in Aberdeen Township through Echo Lake in Kehoe Township.

North of the McMahon Lake Fault, the Gowganda Formation lies unconformably upon Early Precambrian granitic rocks of the Superior Province. South of the fault, the Gowganda Formation lies unconformably upon the Missisagi, Bruce, and Espanola Formations. This beveling of the Quirke Lake Group indicates some folding or tilting and subsequent erosion of the underlying formations occurred before the deposition of the Gowganda sediments.

Within the map-area, the Gowganda Formation consists of two contrasting clastic sequences:

(1) A lower conglomeratic sequence consisting of many intercalated, thin, (probably discontinuous) units of matrix-supported and clast-supported conglomerate, massive to laminated argillite, siltstone, arkose, and dark wacke (Photo 4).

(2) An upper sequence almost entirely composed of massive to laminated argillite and siltstone with interbeds and laminae of pink weathering, fine-grained arkose and arkosic wacke.

[1]The numbers in parentheses refer to property numbers given on Map 2448, back pocket.

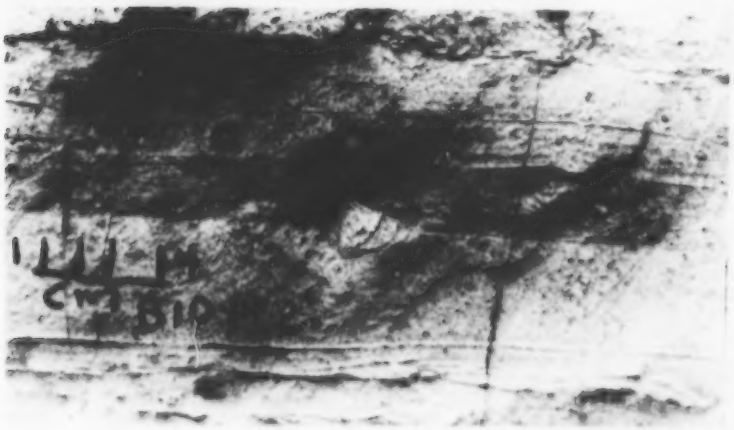
OGS 10 333

Photo 4–Interbedded polymictic, matrix-supported conglomerate and siltstone of the Gowganda Formation. The siltstone beds are from 1 to 3 cm thick and are just below the point of the hammer, at the top of the photo and just below the centre of the photo.

In northwest Chesley Additional Township and in adjacent parts of Kehoe Township, the lower conglomeratic complex is about 600 m thick, while the upper argillite-siltstone member is about 300 to 450 m thick. Similar thicknesses are estimated for these sequences southwest of Two Horse Lake in Aberdeen Additional Township. Elsewhere in the area, sparse outcrop, thick diabase intrusions, and structural complexities make thickness estimates very unreliable.

### *BASAL LITHOLOGIES AND RELATIONSHIPS*

The best exposures of the lower conglomeratic parts of the Gowganda Formation are found northeast of Cuddy Creek in Chesley Additional Township. The erosional unconformity between the Early Precambrian granitic rocks and the Gowganda Formation can be observed directly at several places in this area. It was found that the surface of the unconformity dips very steeply (45 degrees or more) to the west, and even vertical dips were observed in a few places. The granite surface varies from smoothly undulating to angular. There is no evidence of regolith development, but in a few places both the upper surface of the granitic rocks and the basal unit of the Gowganda is ankeritized. About 2.5 km north of the junction of Cuddy Creek and the Echo River, the basal unit of



OGS 10 331

Photo 5–Dropstone in finely laminated gritty siltstone of the Gowganda Formation, Kehoe Township.

the Gowganda Formation is 2 to 3 m thick, and is composed of matrix-supported conglomerate consisting of pink granitic cobbles set in a dark grey wacke matrix. This is overlain by 2 to 3 m of clast-supported conglomerate containing subrounded to well rounded megaclasts of white and pink granite, some are up to 2 m across, cobbles of schistose amphibolite (Archean metavolcanics) with subordinate quartz, felsic volcanic rock, argillite, and syenite megaclasts. This clast-supported conglomerate is overlain in turn by a distinctive laminated grey-green siltstone up to 30 m thick containing units of dropped pebbles, cobbles, and grit. The laminated siltstone-argillite with "drop stones" was traced for at least 3 km along strike near the base of the Gowganda Formation east of Cuddy Creek. In addition to matrix-supported conglomerate, clast-supported conglomerate, pebbly wacke, and laminated siltstone were also observed lying directly upon the granitic rocks in this part of the map-area.

The presence of laminated siltstone with dropped clasts at or near the base of the Gowganda Formation was noted at widely separated localities within the map-area, such as: near the west shore of Echo Lake, and near the southwest shore of Kinch Lake (Photo 5). In general the internal stratigraphy of the Gowganda Formation is far too varied and perhaps discontinuous to allow subdivision over any but a very restricted area.

The unconformable contact between the Gowganda Formation and the Missisagi Formation was observed on the hill which rises steeply from the west shore of Echo Lake. Directly below the Gowganda Formation, the Missisagi Formation is composed of pale grey, thick-bedded subarkose with bedding

defined by very thin discontinuous beds and lenses, in part formed of starved ripples of very fine grained, waxy, pale green wacke. Bedding in the Mississagi Formation just below the unconformity strikes about N42°E and dips about N10°W. A few metres above the unconformity, the bedding in the Gowganda Formation strikes about east-west and dips about 35 degrees to the north. The unconformity itself has a similar strike, but dips about 45 degrees to the north. The upper surface of the Mississagi Formation is finely striated with the striations trending about N24°E and plunging about N40°W. The striations appear more like slickensides than glacial striae, and probably indicate movement along the unconformity during folding.

The basal unit of the Gowganda Formation at this location is about 2 m of a dark grey pebbly siltstone containing about 5 percent subangular pebbles of pink to red granite. No megaclasts of the underlying Mississagi Formation were noted in the rock. A few metres of white weathering greyish green, well-sorted subarkose lies above the pebbly siltstone, and this is superseded by at least 5 m of siltstone, part of which is laminated and contains pebble- to cobble-sized drop stones of pink granitic rocks. The laminated argillite is overlain by a thick unit of pale grey subarkose.

The contact between the Mississagi and the Gowganda Formations was observed about 0.4 km southwest of the above locality, but here, the rocks are highly impregnated by reddish weathering iron carbonate for 2 or 3 m on both sides of the unconformity. Narrow veinlets of carbonate (ankerite) cross the unconformity at high angles. The basal lithology of the Gowganda Formation is polymictic matrix-supported conglomerate.

### *LOWER CONGLOMERATE SEQUENCE*

The lower conglomeratic sequence of the Gowganda Formation of the map-area is a stratified sedimentary complex of sandstone, wacke, siltstone, argillite, and a prominent and varied group of polymictic conglomerates including matrix-supported and clast-supported types.

Brownish weathering ankeritized siltstone was noted 1.7 km northeast of Echo Lake (Photo 6).

Clast-supported conglomerates appear to be more common near the base of the formation, and generally consist of subangular to well rounded boulders up to 2 m across, and cobbles and pebbles of granitic rocks whose variable lithologies are comparable to those of the Early Precambrian basement complex. Schistose amphibolitic rocks (Early Precambrian mafic volcanic rocks), felsite and porphyrite form up to ten percent of some outcrops of matrix-supported conglomerate. Quartz pebbles are generally subangular, and are ubiquitous minor constituents. The sparse matrix of the clast-supported conglomerates is generally poorly sorted arkosic coarse sand and grit.

Individual units of clast-supported polymictic conglomerate are generally devoid of primary sedimentological features.

Matrix-supported polymictic conglomerates are more abundant than clast-supported types. Matrix-supported conglomerates change into pebbly wacke and pebbly siltstone as the proportion of megaclasts falls below 15 percent.

OGS 10 332

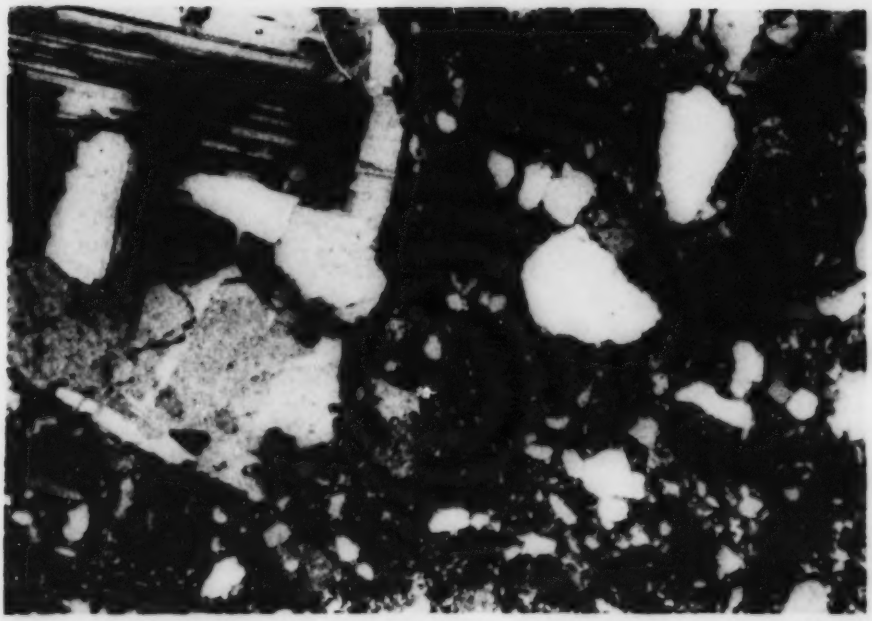
Photo 6–Laminated, ankeritized siltstone of the Gowganda Formation north of Echo Lake, Kehoe Township.

The predominant megaclast is almost always subangular to subrounded pink and grey granitic rocks with subordinate amounts of quartz, felsite, amphibolite, gabbroic and iron formation metasediment megaclasts. Very fine grained, angular, chloritic pebbles with brownish, deeply weathered surfaces were observed in matrix-supported conglomerate of the Gowganda Formation on Marble Point, and northwest of Echo Lake. These clasts are megascopically very similar or identical to clasts of Huronian metabasalt that are so abundant in the Aweres conglomerates of Duncan and Jarvis Townships (Bennett *et al.* 1975, 1976).

Other than these pebbles of Huronian mafic metavolcanics, no readily identifiable Huronian sandstone or conglomerate clasts were observed in the Gowganda conglomerate units. On the south side of the promontory on the west shore of Echo Lake, a few angular chips of limestone, presumably of the Espanola Formation were found in dark grey wacke; but at Marble Point, where the Gowganda matrix-supported conglomerate directly overlies the Espanola Formation, no limestone megaclasts are visible in the conglomerate a few metres above the limestone.

Discrete, irregular, ameboid or twisted, lens-like bodies up to 10 m long of pink weathering arkose and grey siltstone are found within matrix-supported conglomerate units east of Cuddy Creek. In all cases these bodies closely resemble Gowganda lithologies, and indicate mass movement of an unconsolidated, originally stratified sequence.

Matrix-supported conglomerate units seldom display internal stratification or other sedimentological features. Bedding attitudes, however, can locally



OGS 10 334

Photo 7–Photomicrograph of matrix of polymictic matrix-supported conglomerate of the Gowganda Formation, central Kehoe Township.

be determined from narrow interbedded siltstone and argillite units. On the hill on the west side of Echo Lake, and on outcrops in the southeast part of Kehoe Township, finely laminated siltstone beds as thin as 4 cm can be traced continuously for up to 15 m in exposures of coarse matrix-supported polymictic conglomerate. Along the entire length of the exposure no evidence of significant erosion of the thin laminated units such as truncation of laminae exists, but the units are highly attenuated by the overlying megaclasts in the overlying conglomerate. Conglomerate beds between the laminated siltstone beds are from 50 cm to more than 5 m thick. There is no clear clast size gradation across these beds (see Photo 6).

Under the microscope, the matrix of the matrix-supported conglomerate is seen to consist mainly of poorly sorted wacke composed of subrounded to subangular altered plagioclase and generally clear microcline and microcline perthite. Quartz grains are angular to subangular, and show pronounced undulatory extinction (see Table 7 and Photo 7).

The matrix (or sub-matrix) is composed of angular quartz and feldspar grains below silt-size with variable amounts of pale green chlorite, sericite, iron-titanium oxides, and leucoxene. In carbonatized samples, euhedral rhombs of pale brownish carbonate (probably ankerite) up to 5 mm long are dispersed throughout the matrix.

Sandstones are found throughout the conglomeratic succession of the Gowganda Formation, but are particularly abundant and thick in the upper half of the formation. Sandstones of the Gowganda Formation are characteristically pink weathering pinkish grey to greenish grey arkose. Near the west and east shores of Echo Lake, and near Cuddy Creek in southeast Chesley Township, thin beds of pale grey weathering subarkose to arkose are present near the base of the Gowganda Formation. Sandstones seldom display well-developed internal stratification or sedimentary structures. "Ripped-up" chips of argillite can be found near the base of many sandstones beds where they overlie argillite or siltstone.

In thin section, the sandstones are revealed to be arkoses with approximately equal amounts of variably altered plagioclase and microcline. Quartz grains are generally very angular to subrounded, and subspherical. A few grains of metachert and chloritic material (metavolcanic?) are also present. A fine dust of red hematite coats all the grain boundaries of the constituent minerals in the arkose, giving the rock a deep red hue.

### *UPPER SILTSTONE SEQUENCE*

The base of the upper siltstone and mudstone sequence of the Gowganda Formation is considered to be at the top of the uppermost wacke-matrix conglomerate. The lower part of the upper sequence contains many "drop stone" beds, but most of the upper sequence is thinly bedded to laminated dark grey siltstone, argillite, and fine, pink weathering sandstone. "Drop stones" are not seen anywhere in the upper parts of the upper sequence. Sedimentary load structures such as flame structures and ball and pillow structures are common. Graded bedding is locally developed.

Examination of a thin section of grey siltstone shows fine angular grains of quartz, plagioclase, and microcline dispersed in a very fine to sub-microscopic matrix containing quartz, feldspar, and sericite. A few rounded sand balls of wacke a few mm across are dispersed through one thin section.

### *ENVIRONMENT OF DEPOSITION*

Since A.P. Coleman (1908) first suggested a glacial depositional model for the Gowganda Formation, it has been the subject of many studies, and from time to time some controversy. Two relatively recent detailed studies of the Gowganda Formation have been presented as doctoral dissertations by A.T. Ovenshine (1965) and D.A. Lindsay (1967). The Ph.D. Thesis of R.E. Hay (1963), and the work of Casshyap (1966) and F.W. Chandler (1969) have dealt in part with the Gowganda Formation. In addition, many workers of the Geological Survey of Canada and the Ontario Geological Survey have described and commented upon the Gowganda Formation in many government maps and reports.

Most recent writers have agreed with Coleman and stress the importance

of a period or periods of extensive glaciation during the Huronian to account for the somewhat unique features of the Gowganda Formation.

The most important of these features are: the "drop stones", which are interpreted as being ice-rafted, and the matrix-supported conglomerates which are interpretated as fossil glacial tills. Sandstones and clast-supported conglomerates which have features of water laid deposits may be indirectly related to glacial activity (Coleman 1908; Ovenshine 1965; Lindsay 1967; Chandler 1969; and Robertson 1976).

Within the map-area, the Gowganda Formation is a highly stratified complex with very little, if any, clear evidence of paleocurrents. In the case of the clast-supported conglomerate and sandstones, this may be in part the result of the paucity of large continuous exposures. The occurrence of "drop stones" was observed and would seem to suggest some rafting process, presumably ice-rafting, occurred. The most significant feature bearing on the genesis of the matrix-supported conglomerate may be the presence of thin continuous beds of laminated siltstone within massive matrix-supported conglomerate units. It seems unlikely that a conglomerate with abundant cobbles and boulder-sized megaclasts could be deposited as a debris flow or a submarine debris flow without a few cm of erosion through the underlying silt. It is suggested that the conglomerate units may have been deposited from floating ice, as would be the case in a glacial marine, or lacustrine environment.

The amounts of immature sandstone, the highly variable and (apparently) "chaotic" stratigraphy, and the paucity or lack of Huronian clasts in the conglomerates, can be interpreted in terms of, but do not necessarily constitute proof for, a glacial marine environment of deposition for the Gowganda Formation within the map-area.

## Lorrain Formation

The Lorrain Formation underlies much of the southwest and north-central parts of the map-area.

The base of the Lorrain Formation is taken as the top of the upper siltstone-argillite member of the Gowganda Formation. The contact between the Gowganda and Lorrain Formations was not observed in the area, but the outcrop distribution and attitudes suggests that it is conformable.

M.J. Frarey (1975) divided the Lorrain Formation into six members, which are in ascending order; the basal arkose member, the purple siltstone member, lower red quartzite member, jasper conglomerate member, upper red quartzite member, and the white orthoquartzite member.

The current, more detailed survey, supports Frarey's subdivision. The purple siltstone member of Frarey (the red and purple siltstone of this report), however, was found to be a continuous, albeit relatively thin unit within the map-area, and is not restricted to the Desbarats area as indicated by Frarey (1975, 1977). This study also indicates the presence of an additional pink to purple sandstone member overlying the purple siltstone member of Frarey, and which is apparently included in the lower red quartzite of Frarey (1975).

Within the map-area, the Lorrain Formation can be subdivided into at

least seven informal members. This subdivision is in places somewhat arbitrary since contacts between members are often gradational and considerable variation exists locally within individual members. These members are listed below beginning at the base. Thickness estimates are not measured but calculated from (paced) traverses.

**Members of the Lorrain Formation**

| *Member* | *Thickness in Feet and Metres* |
|---|---|
| Pink arkose | About 1000 (300). |
| Red and purple siltstone | 50-200 (15-60). |
| Pink to purple sandstone | 100-200 (30-60). |
| Lower pebbly sandstone | 1000-2,800 (300-860). |
| Jasper pebble conglomerate | up to 400 (up to 120). |
| Upper red pebbly sandstone | 400-600 (120-180). |
| White pebbly sandstone | over 700 (over 210). |

### *PINK ARKOSE*

The lowermost member of the Lorrain Formation in the map-area is a pink weathering, pink to greyish pink, well-sorted arkose. Some beds contain a significant amount of matrix, producing a greyish, arkosic wacke. Near the top of this member, pinkish weathering arkosic wacke is interbedded with pinkish weathering grey siltstone.

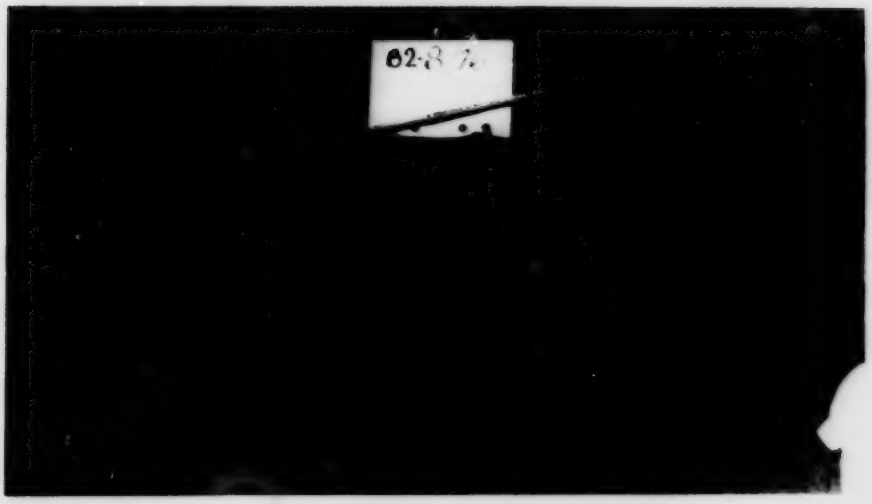
The member is generally thick bedded, but bedding planes are poorly developed and crossbedding was not observed. The arkose resembles those found in the underlying Gowganda Formation.

The grain size is about 0.2 to 0.4 mm with tightly packed plagioclase, microcline, and quartz. Plagioclase grains range from unaltered to almost completely altered. Accessory minerals are chlorite, sericite, iron-titanium oxides, and iron carbonate. The carbonate produces distinctive brownish or orange patches about 5 mm across on the weathered surface of the arkose and arkosic wacke.

### *RED AND PURPLE SILTSTONE*

The pink arkose member of the Lorrain Formation is overlain by a distinctive red and purple siltstone. A thickness of 27 m is indicated from good exposures of this member just south of a private road about 1.6 km west of Fetherston Lake. The pinkish weathering pink arkose passes gradationally over 1 m into a deep red, fine-grained wacke which forms the base of a distinctive sequence of interbedded deep red, medium to very fine grained wacke and red to purple siltstone. Ripple marks are well developed as are flame structures, ball and pillow structures, and disrupted bedding (Photo 8).

Two thin sections from this member were examined by the author. One was a coarse-grained siltstone with an average grain size of about 0.05 mm, and the other a very fine grained quartz wacke with very angular quartz grains about



OGS 10 335

Photo 8–Slump structures in fine-grained sandstone and siltstone, purple siltstone member of the Lorrain Formation.

0.1 mm and subordinate feldspar in a matrix (30 percent) of chlorite, white mica, and very fine grained hematite "dust". Detrital hematite grains about 0.05 mm across form about 2 percent of the rock.

*PINK TO PURPLE SANDSTONE*

The purple siltstone passes upwards into a massive, poorly bedded, medium- to coarse-grained, moderately well sorted quartz-rich sandstone (5-10 percent feldspar). Weathered surfaces are pink or grey: fresh surfaces are variable from pink, green, grey, and purplish grey. This unit contains very few, if any, pebble beds in contrast to overlying pebbly sandstones of the Lorrain Formation.

Two thin sections of this member were examined and found to consist of: subrounded medium to coarse sand-sized quartz (80 percent), chert and jasper (5 percent), and altered and hematite impregnated feldspar (2-5 percent) set in a matrix of fine flakes of white mica (15 percent). There is a little detrital sand-sized hematite, a fine hematite "dust" along grain boundaries, and a few blades of crystalline hematite replacing quartz grains. Zircon and tourmaline are accessory minerals.

OGS 10 336

Photo 9–Trough crossbedding in red sandstone member of Lorrain Formation. Dark pebbles are black and red chert.

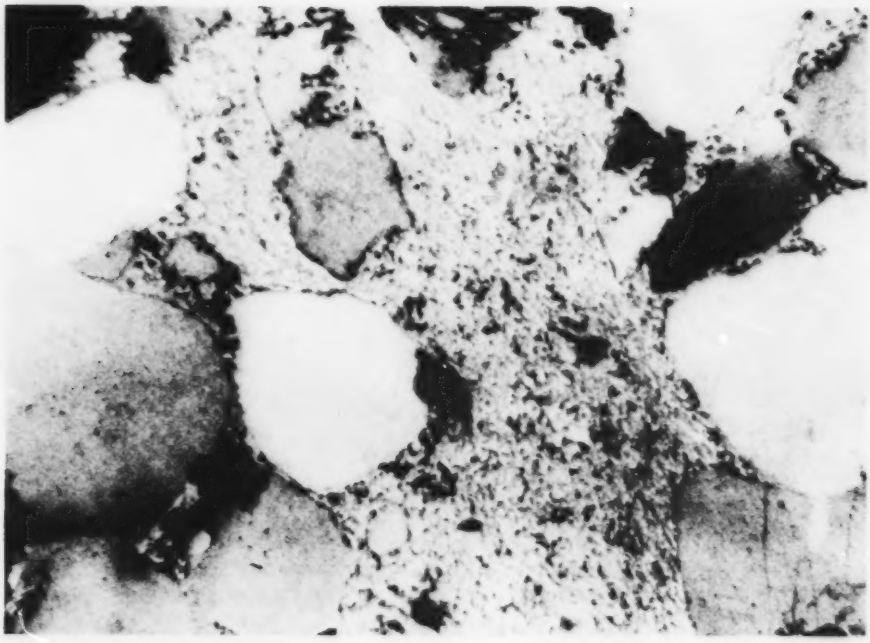
*RED PEBBLY SANDSTONE*

The upper and lower red pebbly sandstone members are essentially similar and the following brief description applies to both.

Pebbly red sandstone members are thick sequences of pink, red, and locally white, poorly sorted coarse ferruginous sandstone with interbeds and lenses of grit, pebbly sandstone, and quartz-pebble conglomerate. Many of the coarse sandstone and conglomerate beds have concentrations of hematite, particularly along the foresets of crossbeds and along the base of conglomerate lenses. These ferruginous beds are dark red to very dark bluish grey or black. Small angular chips and pebbles of jasper are found throughout the red pebbly sandstone members.

Planar and trough crossbedding, ripple-drift crossbedding, scour and fill structures, and slumped and load structures were observed throughout (Photo 9).

Three thin sections of red sandstone examined under the microscope revealed in contrast to the pink to purple sandstone member, the complete absence of feldspar or discernable relict feldspar. The rock is composed of 80 to 90 percent subangular to rounded, poorly sorted quartz grains up to 3 mm across. Finely polycrystalline chert and hematitic jasper (5 percent) are the only other



OGS 10 337

Photo 10–Photomicrograph of red sandstone member of Lorrain Formation. Matrix is mainly pyrophyllite, all sand-sized grains are quartz. Note the thin overgrowth on the largest quartz grain at the left edge of the photo (approximately x 10).

clearly detrital components. Irregular and rectangular tablets of hematite up to 1.5 mm long form 1 to 3 percent of thin sections, and although much or all of this may be detrital, the shapes of the original grains are much modified by overgrowths. Dust trains of hematite within quartz grains reveal overgrowths of up to 0.2 mm thick on some quartz grains. In one thin section, no overgrowth can be directly observed, but the serrated edge of the quartz grains indicates overgrowths have occurred. Secondary hematite blades penetrate the quartz overgrowths, but not the boundaries of the original detrital grains.

The red pebbly quartzite member contains 10 to 25 percent matrix of fine flakes of white mica, prismatic crystals up to 1 mm long of pyrophyllite (Photo 10), and felted masses of kaolinite. The high proportion of matrix indicates that these rocks are quartz wackes and quartz subwackes.

Narrow quartz veins are common throughout the area, but many found in the red pebbly sandstone of the Lorrain Formation are brecciated and contain considerable specular, and red, earthy hematite. A few of these veins also contain crystals of a pale green and yellow waxy mineral identified as pyrophyllite. [Identified by X-ray diffraction, Geoscience Laboratories, Ontario Geological Survey, Toronto].

### JASPER PEBBLE CONGLOMERATE

The jasper pebble conglomerate or "puddingstone", as it is known locally, is one of the most distinctive lithologies of the Huronian succession and certainly the most colourful . An excellent exposure of the jasper pebble conglomerate occurs along a creek about 1.6 km south-southeast of Gap Lake.[1]

The jasper conglomerate consists of angular and well rounded pebbles of quartz and jasper up to 5 cm across in a variable matrix of coarse sand and grit. Pale pink, bright red, maroon, and violet jasper, and some grey and black chert forms up to 70 percent of some beds. Most beds contain 10 to 40 percent jasper pebbles. Bedding is from a few cm to 4 m thick.

### WHITE PEBBLY SANDSTONE

The white pebbly sandstone member of the Lorrain Formation is interbedded with the underlying red pebbly sandstone making the position of the boundary somewhat arbitrary. About 300 m are exposed in northern Kehoe Township.

The member consists almost entirely of medium to thick bedded white, pale grey, and yellowish, moderately well sorted to well sorted, medium- to coarse-grained quartz-rich sandstone. Locally up to 30 percent pale yellow micaceous matrix can be discerned megascopically, and white, powdery interstitial kaolinite is common on freshly broken surfaces. Scattered jasper grit and pebbles are found throughout. Quartz pebbles and thin lenses of quartz-pebble conglomerate are common, but do not appear to be as abundant as in the underlying red pebbly sandstones. Bedding and crossbedding are less conspicuous than in the red pebbly sandstone; no doubt in part due to the lack of colour contrast.

About 1.5 km south of Gap Lake two beds of strikingly bright green to emerald-green sandstone, each about 1.5 m thick are separated by about 2 m of white to pale green sandstone. Chemical analysis and X-ray diffraction patterns of a sample made by the Geoscience Laboratories, Ontario Geological Survey, show that the colouration is due to a chromium-bearing mica, probably fuchsite. Apparently, the occurrence is local as no additional occurrences were found during the 1976 field season. The distribution of the fuchsite suggests that it is primarily a detrital mineral rather than the result of alteration.

The white pebbly sandstone is also devoid of feldspar or relict feldspar outlines. The only clearly detrital grains are subrounded, in part deeply serrated, strained quartz and finely polycrystalline chert. Quartz is predominantly monocrystalline, but some polycrystalline vein quartz is present. A matrix of fine, scaly white mica and coarser blades and radial aggregates of pyrophyllite [The presence of pyrophyllite was verified by the Mineral Research Branch using X-ray diffraction techniques] constitutes about 10 percent of the rock. Zircon is a conspicuous accessory mineral.

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[1]This outcrop, in northeast Kehoe Township, is on the property of Mr. Roy Lewis of Echo Bay. Permission must be obtained to visit the site, where about 25 m of interbedded white pebbly sandstone and a striking jasper conglomerate are exposed.

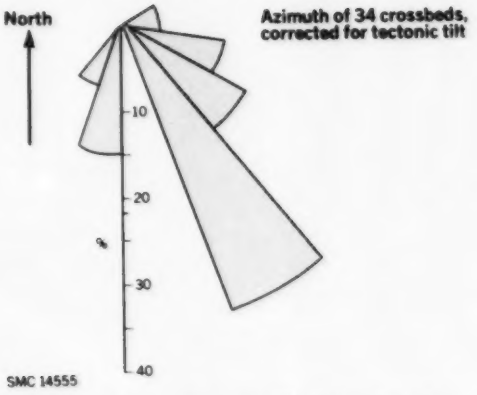



Figure 6–Paleocurrent directions in the Lorrain Formation, Two Horse Lake Area.

*ENVIRONMENT OF DEPOSITION*

Detailed and special studies of the Lorrain Formation in the Elliot Lake and Espanola areas have defined many of the significant features of the formation, but there is still disagreement on some aspects of the environment of deposition. It is generally agreed by most workers that the sandstones of the middle and upper members of the Lorrain Formation are mature or supermature, and were probably derived from older sedimentary rocks (Card 1976, p.24). Wood (1973) suggested that north of Elliot Lake, at Flack Lake, the upper parts of the Lorrain Formation are a fluvial deposit, whereas further south the formation is a beach deposit as proposed by S.M. Casshyap (1967), D.G. Hadley (1968), and Chandler (1969).

Crossbed dip directions in the current map-area are essentially unimodal and suggestive of a fluvial origin for the red pebbly sandstone member (Figure 6).

The presence of aluminous minerals and hematite in the Lorrain Formation is considered to be the result of laterization under tropical weather conditions (Wood 1973; Chandler 1969). The presence of fuchsite in the Lorrain Formation of the map-area is further evidence of intense tropical weathering. Since chromium resembles ferric iron and aluminium in its chemical properties, it is concentrated in some laterite deposits. The metamorphism of chromium enriched weathering products could lead to the formation of fuchsite (Rankama and Sahama 1950, p.623).

The Huronian succession of the North Shore of Lake Huron has been one of the most extensively studied rock sequences of Ontario, yet there is no concensus of opinion on many fundamental questions. Two such questions are: (a) what is the nature of the basin into which the Huronian sediments were transported; and (b) what was the dominant factor in controlling Huronian sedimentation.

The problem of the nature of the basin is summarized by K.D. Card *et al.* (1972). R.S. Dietz and J.C. Holden (1966) suggested that the Huronian succession could be compared with a miogeosyncline or continental rise deposit developed at the margin of the continental crust. This model has failed to gain support because rocks indicative of the presence of oceanic crust (ophiolites) have not been found; nor has evidence of strong compression, such as Alpine type thrust or nappes been found.

M.J. Frarey and S.M. Roscoe (1970) suggested that the Huronian basin represents an exogeosyncline developed near the perimeter of an Archean protocontinent and represented the first development of platform-type sedimentation in the early Proterozoic. The basin shows post-Archean changes in crustal behaviour.

G.M. Young (1971) concluded that the most appropriate model for the Huronian clastic belt is Kay's "parliageosyncline", an essentially tectonically controlled trough developed along a continental margin analogous to the present-day Gulf of Mexico.

W.R. Church (1971) likened the Huronian belt of Ontario to a simple trough formed during an early stage of continental fragmentation rather than continental accretion. As such, it resembles the early stages of Appalachian geosynclines. Support for the latter model has been put forth by D.G. Innes (1977) and Gerald Bennett (in press) who point out that the alkalic aspect of some of the Proterozoic volcanic rocks of the Southern Province may indicate conditions of crustal tension or rifting during the early phases of Huronian sedimentation and basin development.

Two contrasting models have been proposed as controls. One model provides an energy source for Huronian sedimentation in the Southern Province (Siemiatkowska 1978). The other, as proposed by Casshyap (1969), Lindsay (1971), and Young (1973), provides a cyclical glacial control for Huronian sedimentation which involves the formation of extensive continental ice sheets with deposition of sheet-like tills followed by a retreat of the glaciers, marine transgression, and isostatic uplift producing the thick sandstone deposits of the Mississagi, Serpent, and Lorrain Formations.

More recently, Frarey (1977, p.58) has questioned the purely glacial control for Huronian sedimentation, has cited as evidence the stratigraphic continuity of the lowermost and uppermost Huronian formations for which no glacial control has been suggested, and has stated the difficulty of obtaining sufficient uplift through glacial unloading to produce the abundant Huronian sands.

Frarey favours tectonic uplift of the source area as the primary control of Huronian sedimentation. This more conventional alternative to the glacial model is more acceptable to the author. Regional uplift of the source area is necessary to produce the remarkable lithological continuity of Huronian formations. Such uplift should in itself trigger alpine and piedmont glaciers either as a direct result of uplift or by affecting global weather patterns. The glacial advances interpreted from Huronian lithological features may then be the integral part of a tectonic cycle.

## Nipissing Diabase

Mafic sills up to 300 m thick, irregular subconcordant sill-like intrusions of Nipissing gabbro, and related granophyric differentiates form about 20 percent (by area) of that part of the map-area underlain by Huronian formations. Many northwest-striking mafic dikes within the granitic terrain continue into the Huronian rocks, and are considered to be of Nipissing age. It is likely, however, that many mafic dikes cutting the granitic rocks are pre-Huronian, but cannot be distinguished from Nipissing rocks because of metamorphic overprinting.

With the exception of a narrow fine-grained, chilled border zone, the Nipissing intrusions consist predominantly of medium-grained massive gabbro. Where relatively unaltered, the gabbro weathers mottled black and pale grey on fresh surfaces. More altered and metamorphosed varieties are generally grey to greenish grey on weathered surfaces and dark green on fresh surfaces. The essential minerals of unmetamorphosed gabbro are plagioclase (labradorite), orthopyroxene (2V = 63 degrees, bronzite), clinopyroxene (2V = 51 degrees, augite). Accessory minerals are epidote, iron-titanium oxides, quartz, granophyre, apatite, biotite, actinolite, and chlorite (Table 9).

In the altered gabbros, the pyroxenes are completely or largely replaced by pale green actinolite and chlorite. Plagioclase is converted to albite, and the iron titanium oxides are converted to granular sphene or leucoxene and in part to actinolite by reaction with plagioclase. West of Iron Lake and northeast of Gap Lake, the base of the Nipissing sills consists in part at least of peridotite and pyroxenite. The former has been altered to a talc-tremolite assemblage with pseudomorphs of olivine and pyroxene.

Between Lunkie Lake and Pearl Lake in Kehoe Township, a body of gabbro about 600 m wide was emplaced almost perpendicular to the strike of the enclosing Gowganda Formation in contrast to the roughly concordant nature of most of the Nipissing sills of the area. The gabbroic rocks of this body consist almost entirely of distinctly brownish weathering, friable rocks with pale brown, yellowish or grey fresh surfaces. Megascopically, the rocks closely resemble the younger olivine-bearing diabase and gabbro of the Sudbury Swarm. Subsequent thin section examination has revealed a typical tholeiitic mineralogy consisting of labradorite, augite, hypersthene or bronzite, with minor interstitial quartz or granophyre (Table 9). Biotite, iron-titanium oxides, and apatite are accessory minerals. Yellowish, anorthositic phases are present. Near the northeast end of a northeast-trending lake west of Pearl Lake, anorthositic gabbro contains considerable olivine and approaches troctolite (olivine labradorite rock) in composition.

The contact between the brownish gabbros and the grey gabbros which lie immediately to the southwest was not observed directly, but outcrops of the both types occur about 1 m apart indicating a sharp contact.

The position and form of the brown facies of the Nipissing Diabase suggest that it represents a thick keel or feeder below the more typical subconcordant body. It is not clear why the brown gabbro (as a unit) is so free of alteration even where adjacent to the host sedimentary rocks. It is conceivable that the "Pearl Lake Mass" represents a post-tectonic intrusion significantly younger than the Nipissing Diabase.

TABLE 9 | MODAL ANALYSES OF NIPISSING DIABASE, TWO HORSE LAKE AREA .

Modal Analyses in Volume Percent

| Sample Number | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Plagioclase | 64.0 | 55.5 | 73.5 | 75.1 | 46.1 |
| Clinopyroxene | 12.7 | 35.9 | 8.9 | 3.7 | — |
| Orthopyroxene | 7.0 | 5.1 | — | 21.2 | — |
| Olivine + Serpentine | — | — | 17.5 | — | — |
| Amphibole | 1.6 | — | — | — | 38.1 |
| Biotite | 3.7 | 2.3 | — | — | — |
| Epidote | — | — | — | — | 6.6 |
| Fe-Ti Oxides | 1.0 | 1.0 | 0.1 | Tr | — |
| Sphene-Leucoxene | — | — | — | — | 2.3 |
| Chlorite | — | — | — | — | 2.4 |
| Quartz (including granophyre) | 10.0 | 0.2 | — | — | 4.5 |
| | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Location of Samples

1. Granophyric, anorthositic gabbro, Kinch Lake Area, Kehoe Township.
2. Gabbro, Pearl Lake Area, Kehoe Township.
3. Anorthositic olivine gabbro, (troctolitic gabbro) Pearl Lake Area, Kehoe Township.
4. Anorthositic gabbro, Pearl Lake Area, Kehoe Township.
5. Altered gabbro, McDonald Township.

Abbreviation

Tr - Trace

Table 10 gives seven whole rock chemical analyses of Nipissing Diabase from the map-area. A Ne/Q/Ol plot as used by T.N. Irvine and W.R.A. Baragar (1971) indicates that all of the Nipissing Diabase samples analyzed have a subalkaline chemical affinity. Jensen's plot indicates that the Pearl Lake Mass is a high magnesium type, whereas the other analyzed samples of Nipissing Diabase from the map-area are high-iron tholeiites.

Figure 7 compares the Nipissing Diabase of the map-area with those of the Sudbury area (Card and Pattison 1973) on an AFM diagram. The more magnesium-rich nature of the Pearl Lake Mass is apparent, suggesting that it may represent a basal assemblage or keel of the more normal Nipissing gabbro.

**TABLE 10** CHEMICAL ANALYSES OF NIPISSING DIABASE, TWO HORSE LAKE AREA*

Major Components in Weight Percent

| Analysis Number<br>Specimen Number<br>Rock Type | 1<br>M12-15<br>Gabbro | 2<br>M12-14<br>Gabbro | 3<br>M12-6<br>Gabbro | 4<br>M12-17<br>Gabbro | 5<br>M3-2<br>Gabbro | 6<br>M3-11<br>Pegmatite Gabbro | 7<br>M43-3<br>Granophyre |
|---|---|---|---|---|---|---|---|
| $SiO_2$ | 52.3 | 51.4 | 52.5 | 51.2 | 49.3 | 61.5 | 71.7 |
| $Al_2O_3$ | 14.9 | 14.5 | 15.7 | 14.0 | 14.1 | 12.2 | 12.5 |
| $Fe_2O_3$ | 0.90 | 1.46 | 2.52 | 1.39 | 1.80 | 4.76 | 1.13 |
| FeO | 7.89 | 7.32 | 6.83 | 6.58 | 11.5 | 7.24 | 0.89 |
| MgO | 9.47 | 9.86 | 7.52 | 11.3 | 6.82 | 1.32 | 0.44 |
| CaO | 10.7 | 10.9 | 10.1 | 12.1 | 9.36 | 3.88 | 2.09 |
| $Na_2O$ | 1.81 | 2.30 | 2.80 | 1.47 | 2.71 | 3.95 | 4.94 |
| $K_2O$ | 0.62 | 0.75 | 0.39 | 0.32 | 0.71 | 1.33 | 1.45 |
| $H_2O+$ | 0.59 | 1.00 | 0.42 | 1.04 | 1.13 | 0.96 | 0.45 |
| $H_2O-$ | 0.33 | 0.61 | 0.80 | 0.26 | 0.31 | 0.37 | 0.30 |
| $CO_2$ | 0.27 | 0.31 | 0.23 | 0.35 | 0.13 | 0.22 | 1.53 |
| $TiO_2$ | 0.56 | 0.59 | 0.65 | 0.36 | 1.35 | 0.96 | 1.79 |
| $P_2O_5$ | 0.06 | 0.06 | 0.09 | 0.03 | 0.11 | 0.25 | 0.27 |
| S | 0.04 | 0.05 | 0.05 | 0.04 | 0.08 | 0.01 | 0.26 |
| MnO | 0.17 | 0.17 | 0.18 | 0.17 | 0.23 | 0.15 | 0.05 |
| TOTAL | 100.6 | 101.3 | 100.9 | 100.6 | 99.6 | 99.1 | 99.8 |

Notes

| Analysis Number | Description |
|---|---|
| 1 | Gabbro - Pearl Lake Mass. |
| 2 | Gabbro - Pearl Lake Mass. |
| 3 | Gabbro - Pearl Lake Mass. |
| 4 | Gabbro - Pearl Lake Mass. |
| 5 | Gabbro - Southern Kehoe Township. |
| 6 | Gabbro - Southern Kehoe Township. |
| 7 | Granophyre - Northern Aberdeen Township. |

* Chemical analyses by Geoscience Laboratories, Ontario Geological Survey.

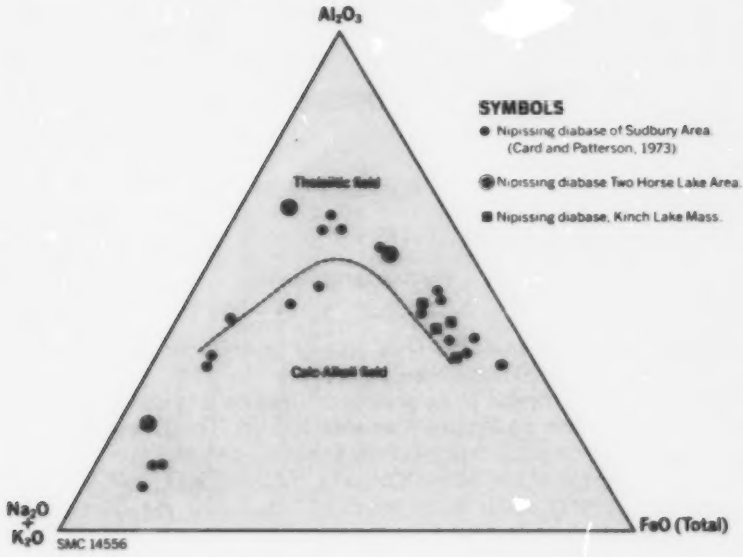



Figure 7–AFM plot for specimens analyzed from the Nipissing Diabase, Two Horse Lake Area.

## LATE PRECAMBRIAN

### Mafic to Intermediate Intrusive Rocks

Unmetamorphosed, post-Nipissing intrusions are rare in the map-area. A few small outcrops of pink, fine-grained felsite found in the general vicinity of Lunkie Lake resemble the Keweenawan felsite dikes of the Sault Ste. Marie area (Bennett *et al.* 1975).

A reddish brown weathering diabase dike about 2 m wide intrudes the Mississagi Formation on the road east of One Horse Lake. The fresh condition of the feldspars and mafic minerals show that the dike has not been metamorphosed.

A narrow biotitic lamprophyre dike intrudes Early Precambrian granitic rocks just north of the Echo River in Chesley Additional Township. Chandler (1973, p.42) gave a detailed description of a lamprophyre from adjacent McMahon Township.

# Phanerozoic

## CENOZOIC

### QUATERNARY

#### Pleistocene and Recent

A summary of the regional Quaternary geology for the area is given by A.N. Boissonneau (1968) and Chandler (1973).

Much of the Two Horse Lake area is covered by a thin mantle of sandy till to bouldery till shown on Figure 8 as ablation till. Thick deposits of sand and gravel are found along the valleys of the Cuddy Creek and the Upper Echo River. Red clay deposits of the Lake Nipissing stage of the Great Lakes (Farrand 1960) support several small farms south of Echo Lake. An elongate deposit of well sorted boulders at an elevation of about 310 m on a hill west of Echo Lake is consistent with the elevation of a Lake Algonquin beach (Farrand 1960).

# METAMORPHISM

Rocks of the Southern Province have been subjected to repeated thermal metamorphic events. An examination of the available radiometric data by Card *et al.* (1972) suggests culminations at about 1950, 1700, 1400, and 1000 m.y. ago. The intensity of these metamorphic events have varied widely throughout the Southern Province, giving alteration assemblages indicative of diagenesis to almandine amphibolite facies of regional metamorphism (Card *et al.* 1972).

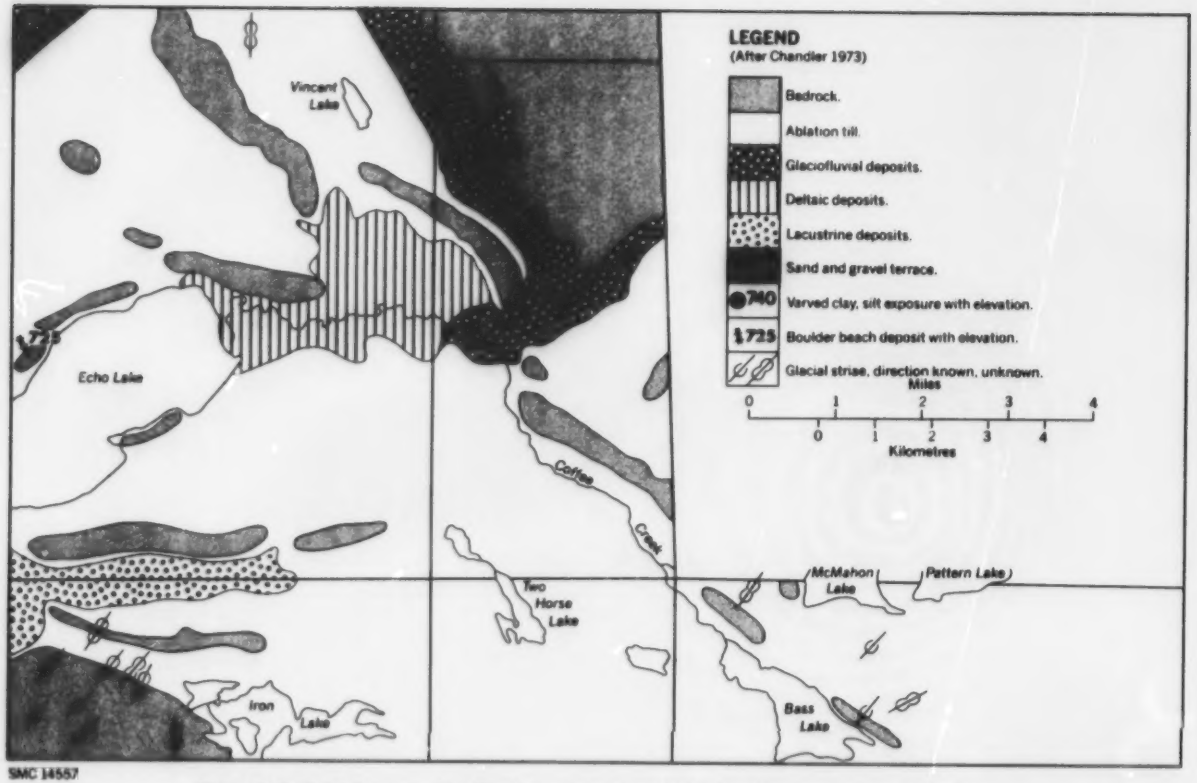
Within the map-area, the presence of abundant chlorite, stilpnomelane, and albite in the metavolcanics, and the presence of pyrophyllite in the Lorrain Formation, indicates that conditions of the lower greenschist facies were attained throughout the stratigraphic succession.

# STRUCTURAL GEOLOGY

## Minor Structural Features

Except where near major faults, the Huronian rocks are not significantly deformed. Tectonic features such as lineation and foliation are not well developed.

Foliation can be discerned in some outcrops of argillite and siltstone of the




SMC 14557

Figure 8–Surficial deposits of the Two Horse Lake Area. Note: the elevations are given in feet.

Gowganda Formation and in the metavolcanics of the Thessalon Formation. In most cases, the foliation strikes northeast and is vertical or dips to the southwest at a steeper angle than the bedding.

## Folding

Throughout most of the map-area, the Huronian formations dip from S20°W to S50°W, suggesting that they lie on the northeast limb of a regional synclinorium.

Local departures from the southwest dips are found in the Gowganda Formation northwest of Echo Lake. Here, open folds with amplitudes of a few metres or less plunge from S15°E to S25°E and have steeply dipping axial planes. These folds and a few northeasterly dips measured north of Kinch Lake have probably developed in response to stresses developed adjacent to major faults.

Bedding attitudes west of Echo Lake indicate an open fold exists in the Mississagi and Gowganda Formations of that area.

## Faults

Northwest- and northeast-striking faults are the dominant structural features of the map-area, and reflect the regional fracture pattern (Ayres *et al.* 1971). These faults are defined over much of their length by negative topographic lineaments and the abrupt termination of geological formations. In only a few places was direct evidence of faulting such as shearing and brecciation observed. This is no doubt largely due to the paucity of outcrop adjacent to the faults.

The Bass Lake Fault extends in a northwest direction through Bass Lake and the north part of Echo Lake. In 1969, The Gulf Minerals Company Limited, drilled two widely separated, vertical diamond-drill holes through this fault. The drill logs indicate that the drill was collared in sandstones of the Mississagi Formation, but passes through a breccia and sheared zone into siltstones and conglomerates characteristic of the Gowganda Formation. The position of the holes indicates that the Bass Lake Fault is a reverse fault dipping 40 to 60°S.

The McMahon Lake Fault, identified by Chandler (1973), has been traced from McMahon Lake in McMahon Township through Pearl Lake in the northwest part of the map-area. The McMahon Lake Fault roughly parallels the Bass Lake Fault, and like the latter, has a downthrown northeast block. The juxtaposition of Early Precambrian plutonic rocks and the upper part of the Lorrain Formation in the Pearl Lake area indicates at least 2500 m of vertical movement in this area.

Examples of northeast-striking faults are the Echo River Fault (Chandler 1973) which can be traced along the Echo River to Echo Lake; and the Lunkie Lake Fault in the northwest corner of the map-area. The truncation of topographic lineaments suggests that the McMahon Lake Fault has displaced these two northeast-trending faults.

# ECONOMIC GEOLOGY

## Uranium

The occurrence of uraniferous quartz-pebble conglomerates at or near the base of the Thessalon Formation has been known for some time (Frarey 1977), but to date none of these conglomerates have shown sufficient grade or tonnage to allow profitable extraction. In spite of the relatively small size of the deposits found to date they are widely distributed along a specific stratigraphic position (for example at or near the base of the Thessalon Formation) from Duncan Township in the west (Hay 1964) as far east as Nicholas Township (a distance of about 100 km; Resident Geologist's Files, Ontario Ministry of Natural Resources, Sault Ste. Marie).

Since the author has identified the Matinenda Formation as overlying the Thessalon Formation (Bennett 1977a, 1977b), the uraniferous conglomerates discussed here are not equivalent to the Matinenda Formation. These rocks differ megascopically from the uraniferous conglomerates of the Matinenda Formation in that the former lacks the abundant sericite which produces the distinctive apple green of much of the sandstone and conglomerate of the Matinenda Formation. In contrast to the Matinenda Formation, uraniferous conglomerates and associated arkoses of the Thessalon Formation commonly contain abundant coarse pink feldspar.

An occurrence of quartz-pebble conglomerate near the base of the Thessalon Formation about 400 m south of the east end of McMahon Lake, was found to be weakly radioactive (two to three times background). The conglomerate is about 1 m thick and dips about 35°S. Angular to subrounded quartz grit and large pebbles of quartz are set in a matrix of poorly sorted pink feldspar and sand-sized quartz. Subangular and subrounded pebbles of mafic volcanic rocks form up to 40 percent of the rock.

Quartz-pebble conglomerate outcrops at about the same stratigraphic level just southeast of the map-area in lots 3 and 4, concessions IV and V of Aberdeen Township. In 1965, Riocanex Limited drilled five holes totalling 472.1 m on this prospect. In 1969, Amax Exploration, Incorporated, drilled an additional 475.1 m in an attempt to locate a mineable zone. The best assays reported are 0.110 lbs/ton $U_3O_8$ over 0.5 m.

The much lower radioactivity of the occurrence south of McMahon Lake is probably due to the dilution of the radioactive quartz-pebble conglomerate by non-radioactive, local, volcanic detritus.

## Copper and Iron

In addition to vein-type chalcopyrite deposits, chalcopyrite occurs in association with magnetite, within a skarn deposit in Aberdeen Additional Township. The skarn is apparently the result of baking and metasomatism of the Espanola Formation limestone at the contact with a large Nipissing Diabase intrusion.

## Cobalt

A steel-grey cobalt-bearing mineral (cobaltite?) and associated cobalt bloom occurs within massive granophyritic areas in Nipissing Diabase east of the south end of Echo Lake in Kehoe Township (W.N. Pearson, Geological Survey of Canada, personal communication, 1978). The occurrence was drilled by Pitch-Ore Uranium Mines Limited in 1955 (see account on "Pitch-Ore Uranium Occurrence").

## Copper

Most of the copper occurrences within the Huronian belt (and adjacent granitic basement) along the North Shore of Lake Huron consist of disseminated to massive chalcopyrite within veins of white quartz and calcite (locally ankerite). Hematite is a common accessory, and bornite locally accompanies chalcopyrite.

Many of these copper-bearing veins occur within Nipissing Diabase (such as the Bruce Mines deposits) or "near" Nipissing Diabase. W.H. Collins (1925, p.116) stated the copper, gold, and silver-cobalt deposits of the North Shore area were associated with diabase which he considered to be Keweenawan, but are presently known to be Nipissing Diabase.

On the east boundary of Chesley Additional Township, between Coffee and Stuart Creeks, a quartz vein about 20 cm thick trends about N60°W in sheared altered Nipissing Diabase. Mineralized patches a few cm across are estimated to contain about 2 percent combined pyrite and chalcopyrite. Some malachite is present as a weathering product of the chalcopyrite.

## Descriptions of Properties and Occurrences

### AUSTIN OCCURRENCE (1)

Following a brief visit to the area, A.P. Coleman noted that the Austin Copper Mining Company (also referred to as the Austin Mining Company) had sunk two (short) shafts and had driven an adit into a copper occurrence north of Echo Lake in Kehoe Township, but that the property had been abandoned several years previously (Coleman 1899, p.124).

In 1955, Lock City Copper Mines Limited, did additional rock trenching and some diamond drilling on the above deposit, but the results are not available. Denison Mines Limited conducted electromagnetic and self-potential surveys, as well as some geological mapping on the occurrence in 1962. One diamond-drill hole was drilled to 12 m, but results did not warrant further expenditure.

The Austin copper prospect is located about 1.5 km northwest of the north-

west end of Echo Lake. A trail from Echo Lake to the workings is now largely overgrown.

Copper mineralization occurs in an arcuate zone of highly variable width (generally less than 3 m) and extends for about 300 m in a northwest to westerly direction. The mineralization consists of erratic seams of chalcopyrite and pyrite and hematite within quartz veins (up to 60 cm wide) and following fractures in siltstone. The siltstone is locally altered (probably silicified and albitized) to a white or pink rock within the mineralized zone. Of 19 channel samples analyzed for Denison Mines Limited in 1968, only four returned over 1 percent copper. The best assays were 2.50 percent copper over 10 feet, 0.05 ounce of silver per ton, and a trace of gold. A grab sample taken by members of the author's field party in 1976 was analyzed by the Geoscience Research Laboratories, Ontario Geological Survey, and returned 11.0 percent copper, 0.29 ounce of silver per ton, and 0.03 ounce of gold per ton.

## CANADIAN JOHNS-MANVILLE COMPANY LIMITED [1968] (2)

In November of 1968, Seigel Associates Limited, on behalf of Canadian Johns-Manville Company Limited, carried out a combined airborne electromagnetic, magnetic, and radiometric survey over a block of 128 claims in Aberdeen, Aberdeen Additional, and Chesley Additional Townships. In all, 206 line miles were flown of which 76 cover the actual claim blocks. Most of the northern halves of Aberdeen Township, and the southern half of both Aberdeen Additional and McMahon Townships were covered by the survey.

Other than magnetic anomalies related to intrusions of Nipissing Diabase, no geophysical anomalies were detected within the current map-area.

## CHESLEY ADDITIONAL TOWNSHIP CHALCOPYRITE OCCURRENCE NO.1

This occurrence is shown on the preliminary geological map of McMahon Township (Chandler 1970). No description is available other than that it is a small occurrence associated with Nipissing Diabase (Chandler 1970). It was not examined during the summer of 1976.

## ECHO LAKE OCCURRENCE (3)

During the course of geological mapping, an exploration trench and about 100 m of spilled diamond-drill core were found about mid-way between the north shore of Echo Lake and Fairly Lake in Kehoe Township.

The trench was dug in sheared, ankeritized arkose and siltstone of the Gowganda Formation, and a vein of vuggy, ankeritic quartz was partly exposed at its northwest end. The vein probably strikes about northwest-southeast, judging from the position of the drill set up. No sulphides are visible in the pit or drill core, but samples containing up to 20 percent pyrite, 5 percent chalcopy-

rite, and 5 percent magnetite, can be found on a small rock dump beside the pit. A sample from the dump analyzed by the Geoscience Laboratories of the Ontario Geological Survey, was found to contain 0.05 ounce of gold per ton, 2.36 percent copper, and trace amounts of lead and silver.

## ECHO RIVER OCCURRENCE (4)

Three partly debris filled pits were dug in siltstone and argillite of the Gowganda Formation on the south side of an abandoned logging road which follows the valley of the Echo River. The pits are located about 2.5 km east of the junction with the road along the east shore of Echo Lake.

The siltstone is brecciated and intruded by quartz stringers striking northwest, and dipping steeply to the south. The adjacent dump contains samples with up to 15 percent pyrite in the breccia matrix and about 2 percent chalcopyrite as seams and blebs. There is no record of this work in the Resident Geologist's Files, Ontario Ministry of Natural Resources, Sault Ste. Marie.

## F. GUILLEMETTE, P. LAVERDIERE, AND L.A. LAFRAMBOISE (5)

In 1962, A.L. Laframboise optioned to Conwest Exploration Company Limited, a 33-claim group located between Hart Lake and Two Horse Lake in Aberdeen Additional Township. Conwest Exploration Company Limited carried out a trenching program and drilled five diamond-drill holes totalling 209 m to evaluate a chalcopyrite- and magnetite-bearing skarn.

As of June 1976, eight claims of the original group are held by F. Guillemette, P. Laverdiere, and L.A. Laframboise.

The trenching and diamond drilling by Conwest Exploration Company Limited outlined a copper-bearing lens about 43 m long with a maximum surface width of 11 m near the centre. The lens strikes about S55°E and dips about S40°W.

In spite of the encouraging results of the trench sampling (3.2 percent Cu over 5 m, 3.0 percent Cu over 11 m, 6.3 percent Cu over 3 m) the diamond drilling failed to intersect sufficient ore-grade mineralization to warrant additional exploration expenditure. The only assays submitted with the logs indicate 1.46 percent copper over a length of 40 cm and 0.70 percent copper over a length of 70 cm.

In 1964, the property was optioned to New Senator-Rouyn Limited who did additional sampling, a ground magnetometer survey, and drilled 28 diamond-drill holes totalling 870.8 m.

The diamond-drill programme outlined a body of maagnetite-rich skarn probably continuous over about 550 m which analyzed from 40 to 50 percent Fe over widths of 3 to 6 m. Unfortunately, the chalcopyrite located at the northwest end of the magnetite zone could not be traced further in grade or tonnage. The option was not renewed.

In July 1976, the author visited the property and examined three of the

eight trenches. Chalcopyrite in coarse patches and seams is distributed throughout coarse, black to very dark green amphibolite skarn which locally contains much magnetite. The poor exposure and partly filled condition of the trenches did not permit any observations regarding the distribution of the mineralization. A selected grab sample taken by the writer was analyzed by the Geoscience Laboratories, Ontario Geological Survey and returned 8.00 percent copper and trace of gold and silver.

## GULF MINERALS CANADA LIMITED [1970] (6)

In 1968, Gulf Minerals Canada Limited, acquired a large block of ground including all of Kehoe and Chesley Additional Townships, as well as much of McMahon, Morin, MacDonald, Meredith, Aberdeen Additional, Aberdeen, and Galbraith Townships. In addition to exploration rights obtained by agreements with patent holders, a total of 363 claims were staked by Gulf Minerals Canada Limited. The project was undertaken with the aim of locating Elliot Lake-type uranium deposits within Elliot Lake Group strata if such a deposit could be identified at the surface or within drilling depth.

In November 1968, Gulf Minerals Canada Limited contracted Seigel Associates Limited to carry out airborne electromagnetic, magnetic, and radiometric surveys of the property.

In 1968 and 1969, David S. Robertson and Associates conducted a geological field examination of the Gulf Minerals ground, and in 1970 a geological field party personnel from Gulf Minerals Canada Limited did geological mapping over much of the area.

In 1969 four diamond-drill holes totalling 1300 m in length were drilled in an attempt to intersect the Matinenda Formation. The holes were stopped when it was found that the Mississagi Formation, on which three of the holes were collared, was thrust upon the Gowganda Formation, making it impractical to continue drilling to the Elliot Lake Group strata.

## D. MORNINGSTAR (7)

A quartz-carbonate vein from 0.3 m to 6 m in outcrop width strikes N45°W and dips about S30°W on the west face of a diabase ridge about 900 m southeast of Vincent Lake in the northeast corner of Kehoe Township. The vein contains sporadic pods and disseminated grains of pyrite and subordinate chalcopyrite with some magnetite, hematite, and malachite staining. A grab sample collected by members of the author's field party during the 1976 field season was analyzed by the Geoscience Laboratories of the Ontario Geological Survey and found to contain 0.17 percent copper with trace nickel, silver, and gold.

In 1956, A. Dolan held a seven claim group SSM 52072-77 and SSM 53456 which included the chalcopyrite occurrence. Five diamond-drill holes totaling 311.5 m in length were drilled by A. Dolan in that year. Drill logs in the Resident Geologist's Files at Sault Ste. Marie, indicate quartz stringers bearing

only scattered grains of chalcopyrite were intersected in the holes. There is no record of recent work on this occurrence.

## PITCH-ORE URANIUM OCCURRENCE (8)

Two grab samples taken by Sylvanite Gold Mines Limited in 1955 from trenches in granophyric Nipissing Diabase, 2000 m south of Marble Point in Kehoe Township, are reported to contain 3.14 percent copper, and 7.0 percent cobalt, nil copper, and 2.26 percent cobalt respectively.

In 1955, Pitch-Ore Uranium Mines Limited optioned the occurrence from Dr. J.E. Gimby of Sault Ste. Marie and drilled six holes totalling 191 m in length. Drill logs in the Resident Geologist's Files, Ontario Ministry of Natural Resources, Sault Ste. Marie, indicate that the predominant rock type at the showings is "granodiorite", presumably the granophyric facies of the Nipissing gabbro. Disseminated grains of pyrite, chalcopyrite, and an unidentified "silver coloured" mineral are reported in the core. The best assays reported are 0.5 percent copper over a length of 0.63 m and 0.68 ounce of silver per ton over a length of 0.6 m.

There is no report of further work on this occurrence.

The occurrence was visited by the author's assistants in July 1977. They reported narrow stringers and coarse disseminated grains of chalcopyrite in, and adjacent to, veinlets of white calcite in altered Nipissing Diabase and granophyric diabase. Eight old trenches were located along a northwest-trending mineralized zone in the diabase. There was no evidence of cobalt mineralization.

## RADEX SYNDICATE [1968] (9)

In 1968, the Radex Syndicate did electromagnetic, magnetic, and radiometric airborne surveys over a 51-claim group (101046-62, 101077-93, 101095, 101097-103, 100771-779) in Aberdeen Additional Township. There is no report of follow-up. All claims have since lapsed.

## SABOURIN OCCURRENCE (10)

A report in the Regional Geologist's Files, Ontario Ministry of Natural Resources, Sault Ste. Marie stated that in 1948, R.J. Sabourin held 18 claims (SSM 14302-19) in south-central Chessley Additional Township. A 2 m wide sulphide-bearing quartz vein on claim SSM 14310, strikes N70°W west within sandstone and argillite of the Gowganda Formation near the contact with a large diabase intrusion. The report stated argentiferous galena is the most important sulphide where it fills fractures within the vein. Sphalerite and chalcopyrite are subordinate in amount. Fine-grained disseminated pyrite is reported in an altered zone adjacent to the diabase.

Assay results quoted in the 1948 report stated that four chip samples and two grab samples were taken. The best results were from chip samples which returned 1.46 ounces of silver per ton over 1.5 m with 0.72 percent lead; and 2.24 ounces of silver per ton over 56 cm with 1.65 percent lead.

The report refers to old trenches, presumably representing work done before 1948. As of April 1976, the ground was open for prospecting.

### SAFARI EXPLORATION LIMITED [1974]

In 1970, Safari Exploration Limited held two groups of three and four claims adjoining the Guillemette-Laverdiere-Laframboise property. In that year, induced potential, geochemical, and geological surveys were carried out over the property.

Three diamond-drill holes totalling 160 m in length were drilled in 1974, and failed to intersect significant mineralization. The claims have since lapsed.

## SUGGESTIONS FOR FUTURE EXPLORATION

The Matinenda Formation, where present, lies above the Thessalon Formation and below the Ramsay Lake Formation. It is possible that about 100 m of Matinenda Formation may underlie the Ramsay Lake Formation along the north shore of Bass Lake and Coffee Creek. This possibility should be weighted against the probable fault along Coffee Creek and the fact that the author found the Ramsay Lake Formation to lie directly upon the Thessalon Formation at the east end of the volcanic belt (personal observation of author, 1979).

The area has potential for gold deposits. The Havilah (gold) Mine (a past producer) is located just east of the map-area, and a new gold occurrence in Otter Township is reported in the Northern Miner of December 7, 1978. Gold, like copper, is apparently associated with Nipissing Diabase.

The area has been known to have potential for copper deposits since the discovery of the Bruce Mines deposits in 1846. Unfortunately most of the deposits discovered since then have been too small to allow profitable production. Rising metal prices along with the development of more efficient portable mills may eventually allow the mining of some of these small deposits.

In addition to the chalcopyrite-magnetite skarn of the Espanola Formation, there is an occurrence of sphalerite and galena in the Espanola Formation on the Garden River Indian Reserve just west of the current map-area. The author found a piece of Espanola Formation float containing a thin seam of chalcopyrite on the road near Marble Point in Kehoe Township. The Espanola Formation, especially where intruded by diabase dikes, would seem to be good prospecting ground.

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